MANUAL OF GAIN CORRECTION DATA FOR STANDARD GAIN HORN ANTENNAS

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The purpose of this manual is to provide correction data for the antenna gain when measuring standard gain horns at finite range. A procedure for finite range correction of measured horn coupling data was developed under this contract. This procedure permits the far field gain of a standard gain horn to be determined from on-axis coupling measurements between two horn antennas with finite range separation.

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I. INTRODUCTION

The purpose of this manual is to provide correction data for the antenna gain when measuring standard gain horns at finite range. A procedure for finite range correction of measured horn coupling data was developed under this contract. This procedure permits the far field gain of a standard gain horn to be determined from on-axis coupling measurements between two horn antennas with finite range separation.

The theory and derivations for the finite range corrections are documented in detail in Ref. [1]. This manual contains numerical results for use in determining far field gain values from measured horn coupling data for the horn models listed in Table 1. Also included are correction data for the experimental X-band corrugated horn model CX-20 made by Ladar Systems.

II. BASIC THEORY

The near field gain of an antenna is often defined through the coupling equation

$$\frac{P_R}{P_T} = \left(\frac{\lambda}{4\pi R}\right)^2 G_T(R) G_R(R) \quad . \tag{1}$$

However, this definition causes the near field gain of each antenna to be dependent on the antenna with which it is measured, especially at close range. We have defined the near field gain through its on-axis power density in Ref. [1]. This gives a definition which is independent of the other antenna.

However, Equation (1) is then not exact because the coupling depends on how the two antennas react. Equation (1) is equivalent to assuming each antenna would radiate a uniform spherical wave from

its amplitude center. A more accurate equation for coupling is derived in Ref. [1] which approximates the near axis fields of each antenna more accurately at close range. The more accurate coupling equation is given by

$$\frac{P_R}{P_T} = \left(\frac{\lambda G(R)}{4\pi R}\right)^2 \frac{1}{\sqrt{1+T_E^2}} \frac{1}{\sqrt{1+T_H^2}} \tag{2}$$

where $G(R) = \sqrt{G_T(R)G_R(R)}$, $G_T(R)$ and $G_R(R)$ are the near field gains of the transmitting and receiving horns at distance R between the amplitude centers of the horns as shown in Figure 1. The amplitude center

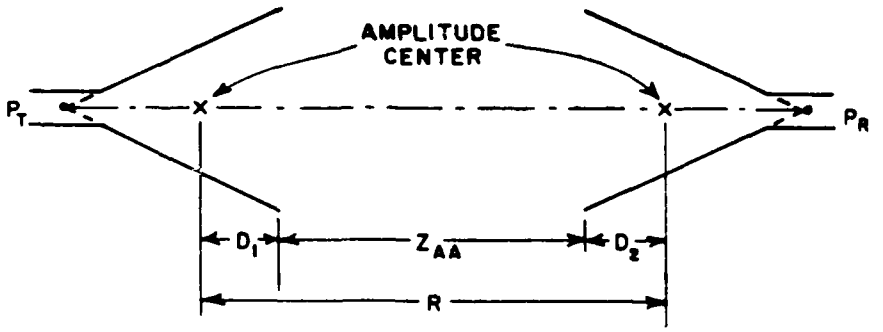

Figure 1. Transmitting and receiving horn antenna geometry.

of a horn is located half way between the E- and H-plane phase centers, or a distance

$$D = \frac{D_E + D_H}{2} \tag{3}$$

from the horn aperture [1].

The phase centers D_E and D_H of a horn are calculated from the far field patterns. The factors $[1+T_{E,H}^2]^{-1/2}$ give more accuracy at close range. From Equation (2) we get

$$G(R) = \frac{4\pi R}{\lambda}\sqrt{\frac{P_R}{P_T}}\left[(1+T_E^2)(1+T_H^2)\right]^{\frac{1}{4}} \quad . \tag{4}$$

The far-field gain $G^{F.F.}$ is determined by using the ratio R_{GAN} of the calculated near field gain G(R) to the calculated far-field gain [1]. Thus the far-field gain can be expressed as

$$G^{F.F.} = \frac{G(R)}{R_{GAN}} = \frac{4\pi R}{\lambda R_{GAN}}\sqrt{\frac{P_R}{P_T}}\left[(1+T_E^2)(1+T_H^2)\right]^{\frac{1}{4}} \quad . \tag{5}$$

We can express the far-field gain in dB as

$$G_{dB}^{F.F.} = R_{GC} + \frac{1}{2}\left(\frac{P_R}{P_T}\right)_{dB}^{Meas.} \tag{6}$$

where R_{GC} includes the near-field gain correction and is given in dB as

$$R_{GC} = 10\ \log\left\{\frac{4\pi R}{\lambda R_{GAN}}\left[(1+T_E^2)(1+T_H^2)\right]^{\frac{1}{4}}\right\} \tag{7}$$

and $\left(\frac{P_R}{P_T}\right)_{dB}^{Meas.}$ is measured coupling in dB.

It is convenient to express the range correction parameter R_{GC} as

$$R_{GC} = R_{GU} + F_C \tag{8}$$

where

$$R_{GU} = 10\ \log\left[\frac{4\pi R}{\lambda R_{GAN}}\right] \tag{9}$$

is the basic range correction parameter (assumes wide beams or large separations). The correction factor for narrow beams at close range is given by

$$F_c = 10 \log \left[(1+T_E^2)(1+T_H^2)\right]^{\frac{1}{4}} = 2.5 \log\left[(1+T_E^2)(1+T_H^2)\right] \qquad (10)$$

where, from Ref. [1],

$$T_E = \frac{C_E}{R} \qquad (11a)$$

$$C_E = \begin{cases} \frac{2\lambda}{\pi} A_E & \text{for like horns} \\ \frac{\lambda}{\pi} (A_{E1}+A_{E2}) & \text{for different horns} \end{cases} \qquad (11b)$$

$$T_H = \frac{C_H}{R} \qquad (12a)$$

and

$$C_H = \begin{cases} \frac{2\lambda}{\pi} A_H & \text{for like horns} \\ \frac{\lambda}{\pi} (A_{H1}+A_{H2}) & \text{for different horns} \end{cases} \qquad (12b)$$

The constants A_E and A_H are determined [1] from the E-plane and H-plane patterns, respectively. The main beam of each pattern can be represented for small angles as a Gaussian function

$$F(\theta) = e^{-A\theta^2} \quad . \qquad (13)$$

The constant A is usually determined from the calculated pattern in dB at $\theta=1^o$. Thus [1]

$$A = - 378\, F_{dB}(1^o) \quad . \qquad (14)$$

However, measured patterns can be used, instead, with the constant A determined at the pattern angle θ in degrees as

$$A = - 378 \frac{F_{dB}(\theta)}{\theta^2_{deg.}} \quad . \qquad (15)$$

It is necessary to measure the coupling over a range of aperture separations in order to average out the ripple caused by interactions between the horn structures. For practical purposes, the coupling value used in Equation (6) can be obtained by drawing a smooth curve through the coupling data as shown in Figure 2.

In summary, we can determine the far field gain by the following procedure:

1. Measure the coupling data, P_R/P_T.

2. Compute the range corrected gain parameter R_{GC}.

3. Determine the far-field gain from Equation (6).

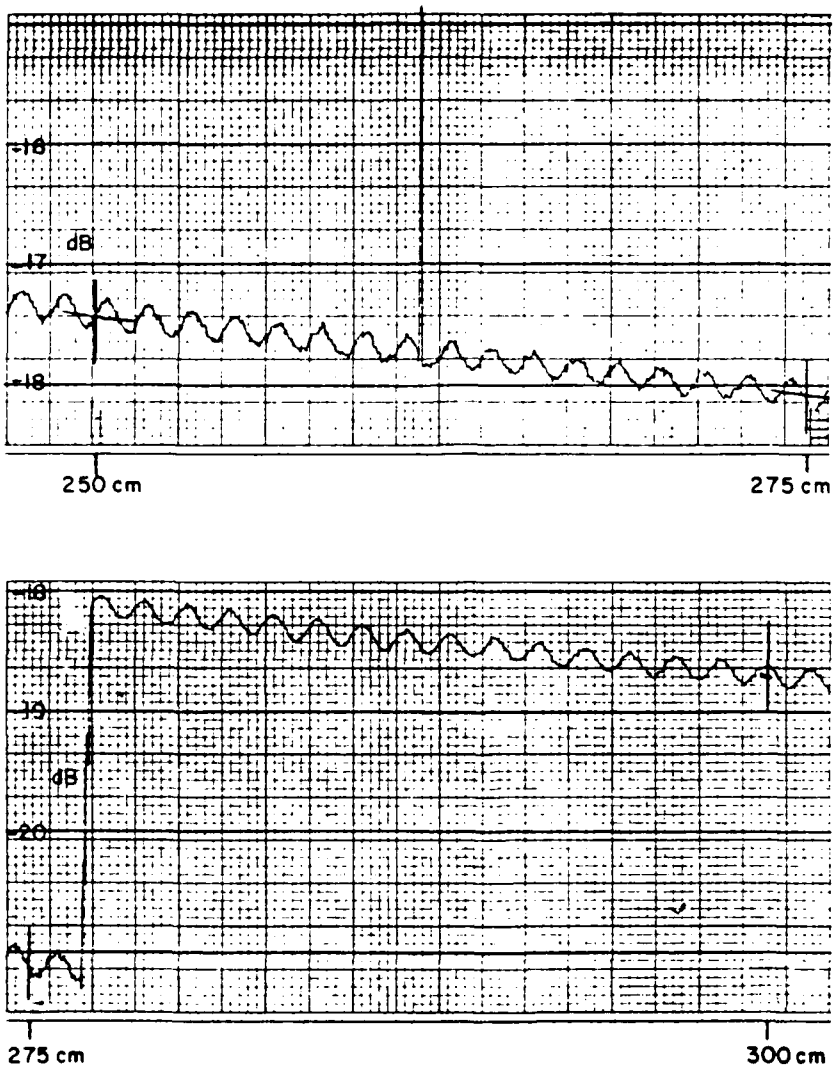

Figure 2. Measured coupling between two SA model 12-8.2 horns at 10 GHz.

III. BASIC PROCEDURES AND SAMPLE RESULTS

The procedures for determining the far-field gain from the near-field measurement of coupling between two horns, using the near-field range correction (R_{GC}) data, are presented in this section. The measured coupling data used in the examples are based on measurements taken at the Measurement Standards and Microwave Laboratory at Newark Air Force Station. The line source integration (LSI) method is used for conventional standard gain horns and the aperture integration (API) method is used for corrugated horns because they are considered to be more accurate than the basic GTD method.

Figure 3a shows the gain ratio or gain correction (R_{GAN}) curve for the Scientific-Atlanta Model 12-8.2 standard gain horn at 10 GHz. We can see here that the gain correction is small (less than 0.2 dB), because the range is measured between the amplitude centers of each horn. For example, the gain correction is about 0.01 dB when the separation (distance between the horn apertures) is 300 cm (100λ at 10 GHz). Figure 3b shows the calculated coupling (P_R/P_T) between two Scientific-Atlanta Standard gain horns at 100 GHz. Figure 3c shows the near-field range correction parameter (R_{GC}) for two Scientific-Atlanta standard gain horns at 10 GHz. Figures 4 and 5 show the near-field correction and coupling curves for the Narda model 640 and corrugated horns, respectively.

The range correction data are given in Tables 2 through 26 for the standard gain horns listed in Table 1. Range correction data are also included for the X-band corrugated horn (Ladar Systems model [illegible]). A list of the variables in each column is given below:

ZAA = Aperture separation in cm.

R = Distance between amplitude centers in cm.

RGAN = Ratio of near field gain to far-field gain.

PRPT = Calculated coupling.

NFGAIN = G(R) = calculated near-field gain.

RGU = Basic range correction parameter.

RGC = Final range correction parameter.

Note that the calculated coupling values PRPT are given only for information purposes. Only the actual measured coupling values should be used with the theoretical range correction parameter RGC to determine the gain.

Procedure for two horns of same model

As an example of how to use the near field range correction tables, consider the following case in which the gain is determined from the measured coupling between two Scientific-Atlanta standard gain horns. The measured coupling curve for aperture separations between 250 cm and 300 cm is shown in Figure 2. The ripple caused by interactions between the horns and their mounting structures has a period of about 1.5 cm for each cycle, which corresponds to $\lambda/2$ as expected. The 0.25 dB peak to peak ripple at 250 cm corresponds to a multipath level from horn interactions of about -37 dB below the direct coupling. A -37 dB multipath will cause a ripple maximum of +0.122 dB and a ripple minimum of -0.124 dB with respect to the direct coupling. Consequently the direct coupling can be accurately measured by drawing a smooth curve through the average of the ripple minima and maxima.

The procedure for determining the far field gain is outlined below:

1. The coupling values are sampled at 250, 275 and 300 cm and are recorded below.

2. Next the theoretical range correction values are read from the appropriate table (Table 11 for SA model 12-8.2 at 10 GHz). These values are also recorded below.

3. The far field gain values are determined for each point from Equation (6) which is repeated below:

$$G^{FF} = R_{GC} + \frac{1}{2} (P_R/P_T)_{dB} \qquad (6)$$

Example of Procedure for Range Correction

Z_{AA} cm	Coupling dB	R_{GC} dB	G^{FF} dB
250	-17.44	30.95	22.23
275	-18.12	31.29	22.23
300	-18.70	31.61	22.26

For example, the coupling at 250 cm is -17.44 dB. The R_{GC} value from Table 11 is 30.95 dB. We get the desired far-field gain from Equation (6) as

$$G_{S/A} = 30.95 + \frac{1}{2} (-17.44) = 22.23 \text{ dB}.$$

Note that the spread in gain values for this example is 22.26-22.23=0.03 dB. Thus this coupling measurement indicates an effective gain for the two horns of 22.24 dB.

Procedure for two horns of different models

The next example shows how to use the tables to determine the range correction for coupling measured between two horns of different models. Three coupling values should be checked as was done in the previous example. However, only one coupling value is used in this example to illustrate the use of the range correction tables for coupling between horns of different models.

First, the distance D_1+D_2 shown in Figure 1 must be calculated. Referring to Tables 11 and 16,

$$D_1 = \frac{1}{2}(D_E+D_H)_{S/A} = \frac{1}{2}(16.98+22.55)_{S/A} = 19.76 \text{ cm}$$

$$D_2 = \frac{1}{2}(D_E+D_H)_{NARDA} = \frac{1}{2}(1.08+1.55)_{NARDA} = 1.32 \text{ cm}$$

$$D_1+D_2 = (D_E+D_H)_{AVG} = (19.76+1.32) = 21.08 \text{ cm.}$$

For an aperture separation Z_{AA} = 150 cm this gives an effective range between horns as

$$R = 150+21.08 = 171.1 \text{ cm.}$$

We get the basic range correction of gain at R = 171.1 cm by interpolating the R_{GU} values from Tables 11 and 16 as follows:

$$(R_{GU})_{S/A} = 28.67 \text{ dB}$$

$$(R_{GU})_{NARDA} = 28.54 \text{ dB}$$

$$(R_{GU})_{AVG} = (28.67+28.54)/2 = 28.60 \text{ dB}$$

Note that the R_{GC} value cannot be directly obtained from the R_{GC} values of the individual horns because the F_c factor in Equation (10) has a non-linear relationship for the two horns. The values of C_E and C_H in Equations (11b) and (12b) can be calculated by averaging the values for the individual horns as given at the top of Tables 11 and 16. Thus

Horn	C_E cm	C_H cm
S/A	66.39	52.71
Narda	12.41	11.59
Average	39.40	32.15

Since R = 171.1 cm for this example, T_E = 0.230 and T_H = 0.188. The correction factor for close range is calculated from Equation (10) as F_c = 0.094 dB. The final range correction R_{GC} for the S/A to Narda coupling at ZAA = 150 cm is calculated from

$$(R_{GC})_{AVG} = R_{GU} + F_c$$
$$= 28.60\ dB + 0.09\ dB$$
$$= 28.69\ dB.$$

The measured coupling for 150 cm between the Scientific-Atlanta to Narda horns was -18.80 dB. Thus the effective far field gain of the two horns is determined as

$$G^{Meas}_{S/A\text{-}Narda} = (R_{GC})_{AVG} + \frac{1}{2}\left(\frac{P_R}{P_T}\right)_{Meas}$$
$$= 28.69 + \frac{1}{2}(-18.80) = 19.29\ dB.$$

The basic procedures described above give the effective gain for each horn pair. A detailed procedure for calibrating the gain of each individual horn is described in Appendix A. This procedure uses 4 antennas and is recommended as a replacement for the three antenna method.

FREQUENCY= 10.000GHZ

DEOH= 39.524CM

A= 19.44 (CM)
B= 14.40 (CM)
LE= 32.00 (CM)
LH= 34.25 (CM)

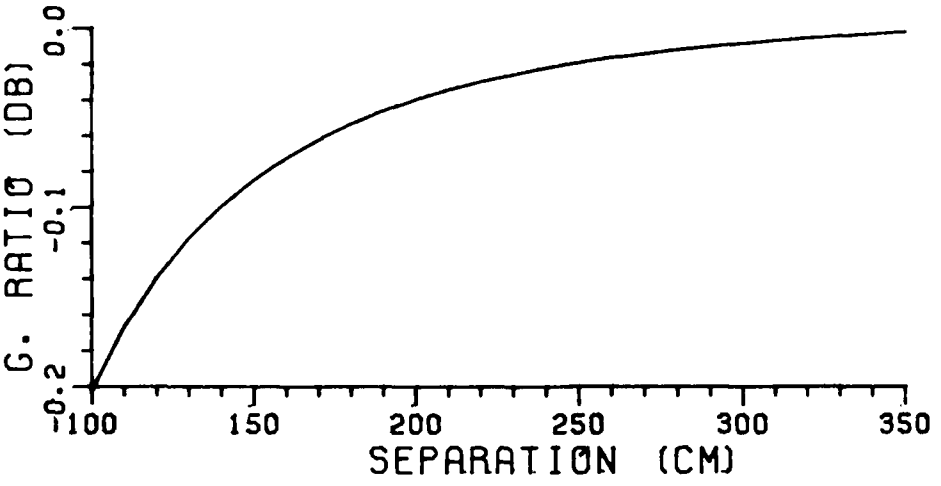

Figure 3a. Gain ratio curve for Scientific-Atlanta standard gain horn at 10 GHz (R_{GAN}).

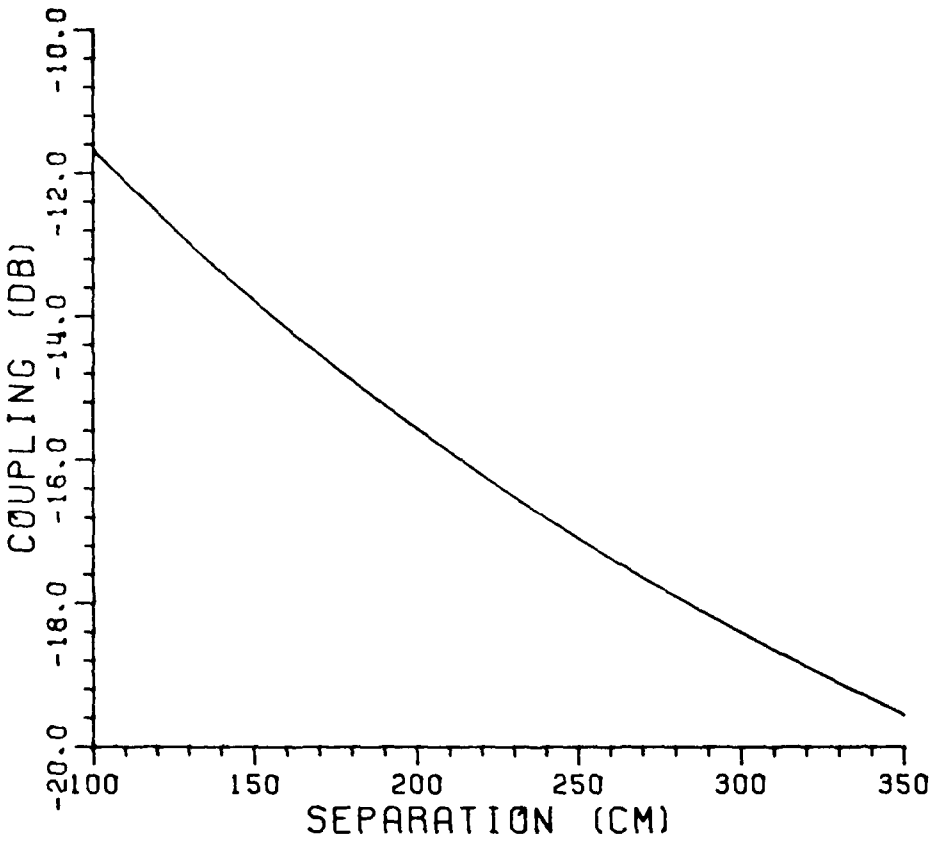

Figure 3b. Coupling between two Scientific-Atlanta standard gain horns at 10 GHz (P_R/P_T).

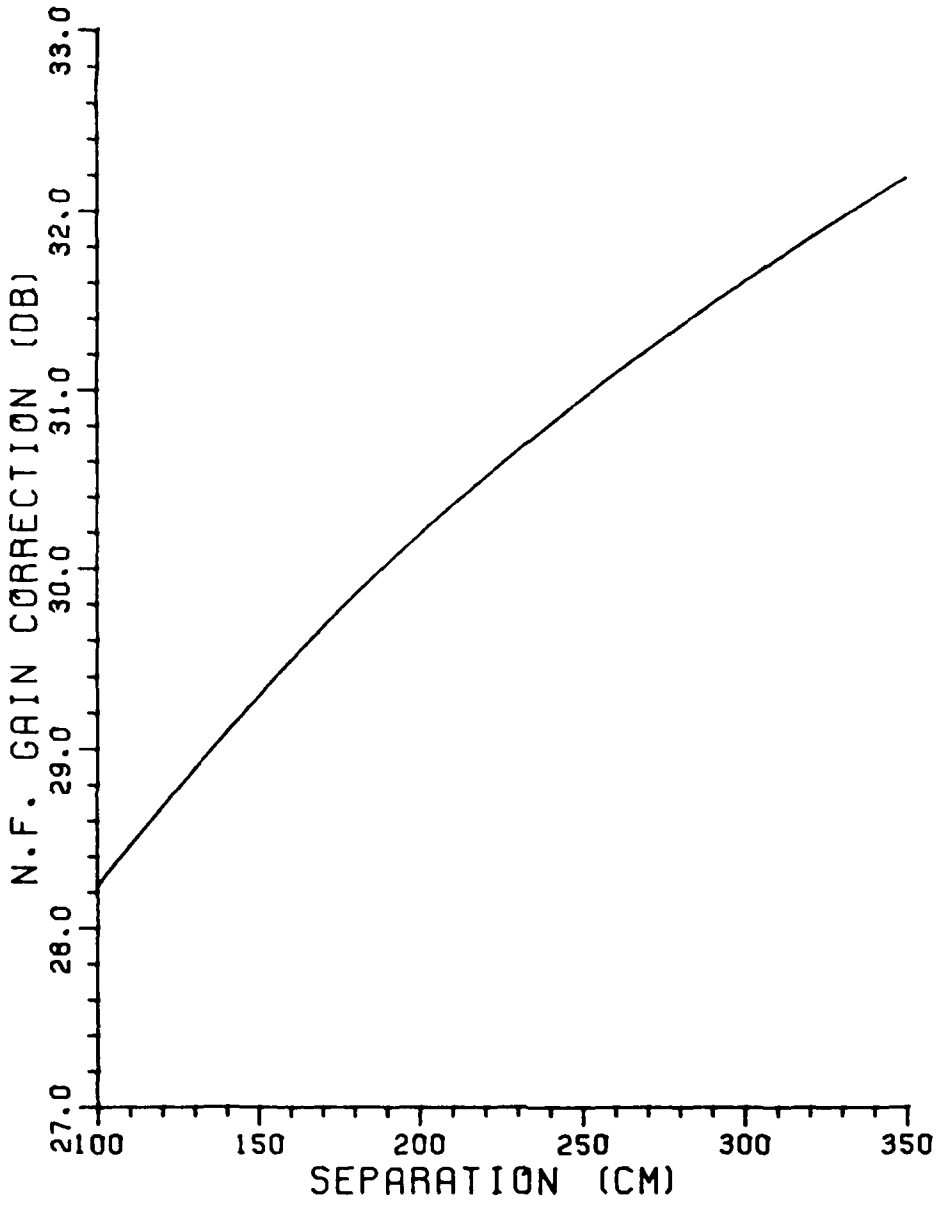

Figure 3c. Near field range correction of gain for two Scientific-Atlanta standard gain horns at 10 GHz (R_{GC}).

FREQUENCY= 10.000GHZ

DEDH= 2.636 CM

A= 7.86 (CM)
B= 5.85 (CM)
LE= 12.75 (CM)
LH= 14.25 (CM)

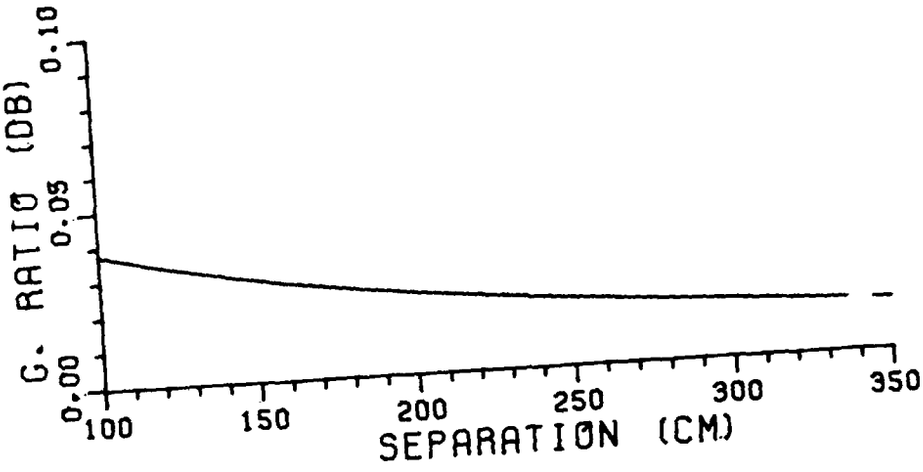

Figure 4a. Gain ratio curve for Narda standard gain horn at 10 GHz (R_{GAN}).

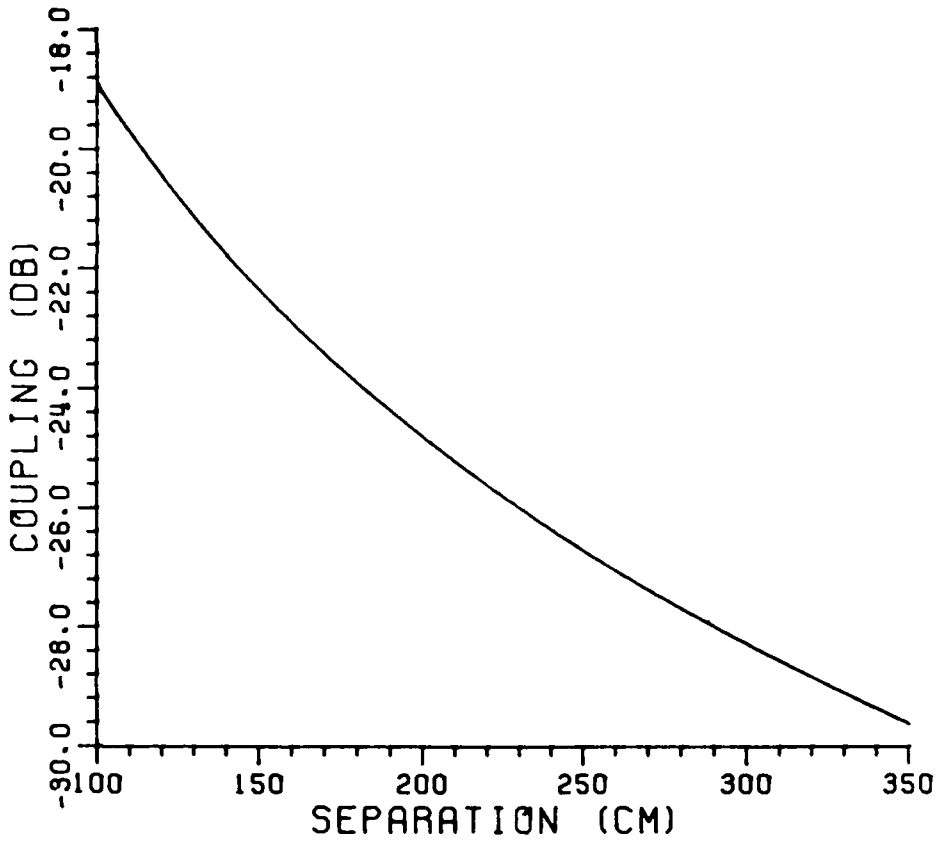

Figure 4b. Coupling between two Narda standard gain horns at 10 GHz (P_R/P_T).

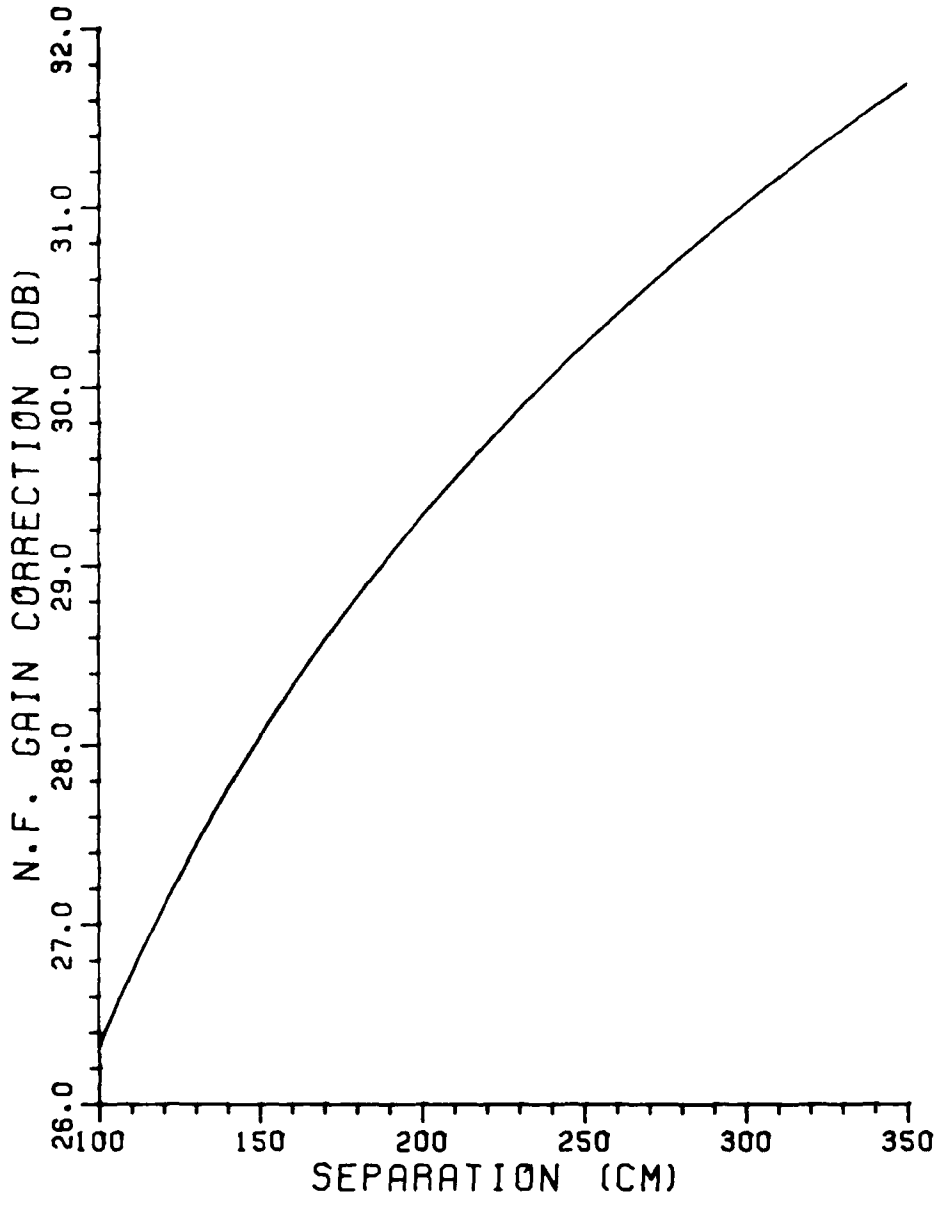

Figure 4c. Near field range correction of gain for two Narda standard gain horns at 10 GHz (R_{GC}).

FREQUENCY= 10.00 GHZ

TDH= 12.42CM

A= 12.65 (CM)
B= 12.65 (CM)
LE= 22.60 (CM)
LH= 24.84 (CM)

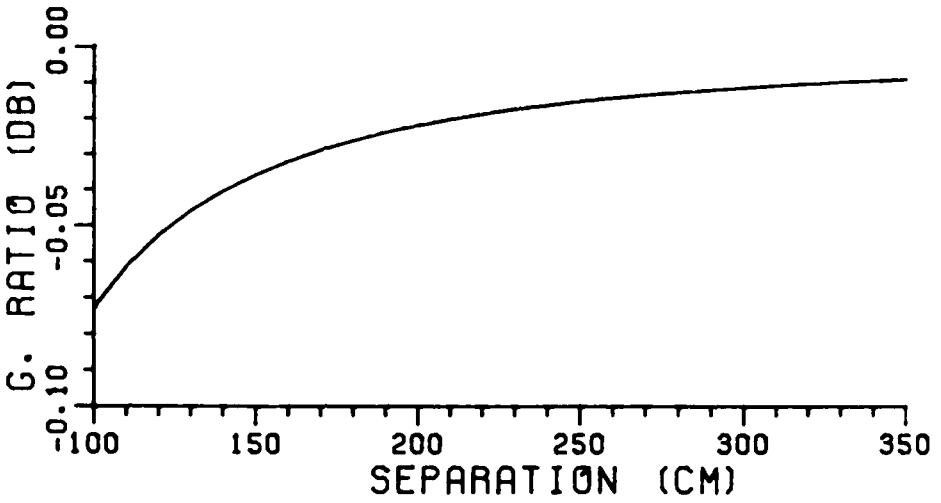

Figure 5a. Gain ratio curve for corrugated horn at 10 GHz (R_{GAN}).

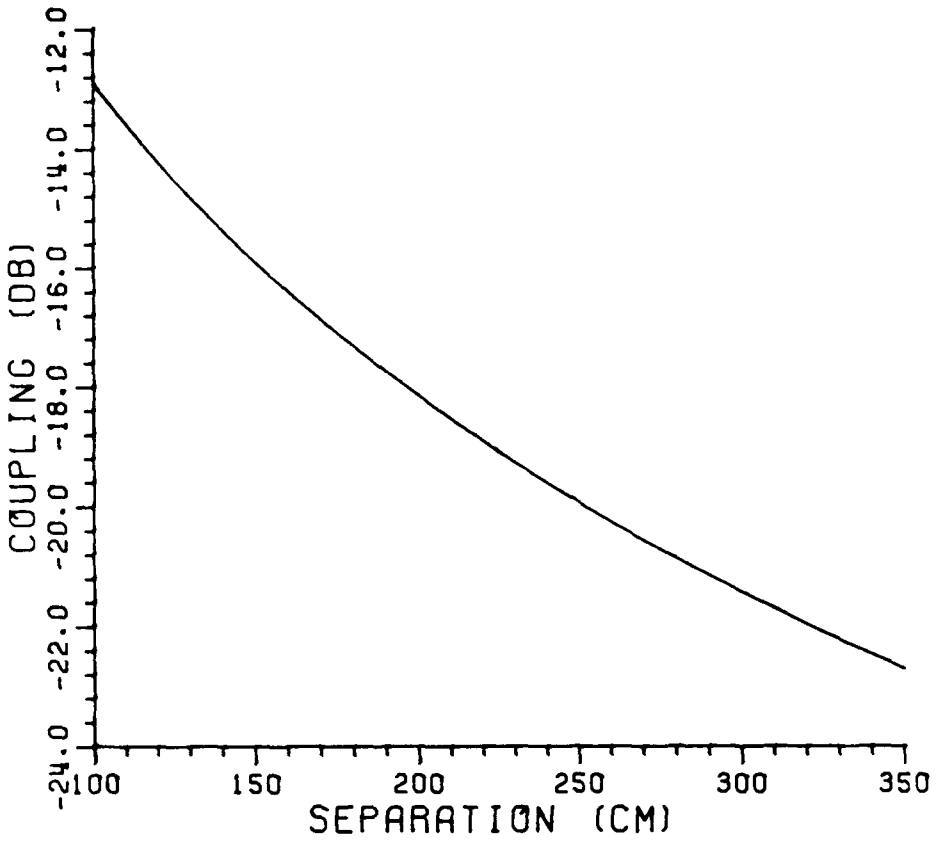

Figure 5b. Coupling between two corrugated horns at 10 GHz (P_R/P_T).

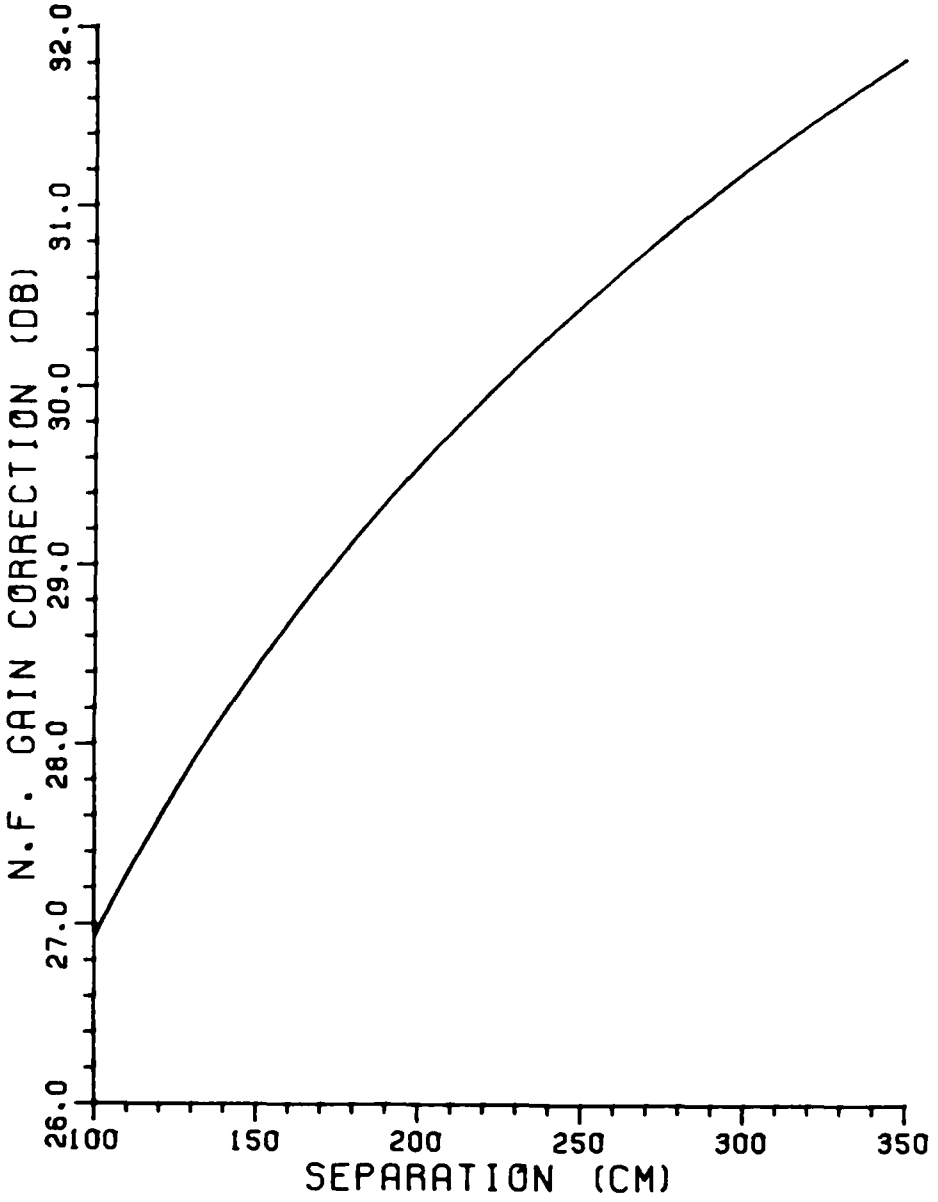

Figure 5c. Near field range correction of gain for two corrugated horns at 10 GHz (R_{GC}).

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of

TABLES

for

RANGE CORRECTED DATA

of

STANDARD GAIN HORN ANTENNA

Table 1: DIMENSIONS OF STANDARD GAIN HORNS

MODEL	FREQUENCY RANGE (GHz)	NOMINAL GAIN (dB)	H-PLANE			E-PLANE		
			A (cm)	L_H* (cm)	$2\theta_{OH}$ (degree)	B (cm)	L_E* (cm)	$2\theta_{OE}$ (degree)
SA12-1.1	1.12- 1.7	15.5	55.70	63.39	52.1	41.26	54.17	44.8
SA12-1.7	1.7 - 2.6	15.5	36.85	41.93	52.1	27.30	35.83	44.8
SA12-2.6	2.6- 3.95	18.0	32.41	47.45	39.9	24.00	42.15	33.1
NARDA 644	2.6-3.95	16.5	23.18	38.54	35.0	17.16	34.27	29.0
SA12-3.9	3.95-5.85	18.0	21.61	31.65	39.9	16.00	28.10	33.1
NARDA 642	5.4-8.2	16.5	11.18	19.98	32.5	8.30	16.86	28.5
SA12-5.8	5.85-8.2	22.1	28.85	50.84	33.0	21.37	47.50	26.0
SA12-8.2	8.2-12.4	22.1	19.44	34.25	33.0	14.40	32.00	26.0
NARDA 640	8.2-12.4	16.5	7.86	14.25	32.0	5.95	12.75	27.0
LADAR CX-20	8.2-12.4	20.5	12.65	24.84	29.5	12.65	22.60	32.5
NARDA 639	12.4-18.0	16.5	5.05	8.40	35.0	3.70	7.65	28.0
NARDA 638	18.0-26.5	16.5	3.33	6.23	31.0	2.54	5.07	29.0
SA12A-26	26.5-40.0	24.7	6.91	16.54	24.1	5.67	15.74	20.7

*The slant lengths for the curved Narda horns were calculated by:

$L_H = A/2\sin\theta_{OH}$; $L_E = B/2\sin\theta_{OE}$

Table 2: Range Correction Data for SA Model 12-1.1

*****LSI***** ((FREQUENCY= 1.300 GHZ))
DE= 10.18 CM DH= 15.02 CM CE= 76.15 CM CH= 69.48 CM
B= 41.26 CM(1.7880 LAMDA) A= 55.70 CM(2.4139 LAMDA)
EL= 54.17 CM(2.3472 LAMDA) HL= 63.39 CM(2.7467 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
8067.84	8093.03	0.00000	-41.614	15.635	36.441	36.442
100.00	125.20	-0.16132	-6.993	15.473	18.498	19.131
110.00	135.20	-0.11675	-7.412	15.518	18.787	19.340
120.00	145.20	-0.08292	-7.832	15.552	19.063	19.551
130.00	155.20	-0.05686	-8.248	15.578	19.326	19.759
140.00	165.20	-0.03655	-8.657	15.598	19.577	19.963
150.00	175.20	-0.02054	-9.056	15.614	19.816	20.163
160.00	185.20	-0.00783	-9.445	15.627	20.045	20.357
170.00	195.20	0.00235	-9.823	15.637	20.263	20.546
180.00	205.20	0.01054	-10.190	15.645	20.472	20.729
190.00	215.20	0.01717	-10.545	15.652	20.672	20.907
200.00	225.20	0.02253	-10.890	15.657	20.863	21.080
210.00	235.20	0.02690	-11.224	15.662	21.048	21.247
220.00	245.20	0.03045	-11.548	15.665	21.225	21.409
230.00	255.20	0.03335	-11.863	15.668	21.396	21.566
240.00	265.20	0.03569	-12.168	15.670	21.560	21.718
250.00	275.20	0.03760	-12.463	15.672	21.719	21.866
260.00	285.20	0.03912	-12.751	15.674	21.873	22.010
270.00	295.20	0.04034	-13.030	15.675	22.021	22.150
280.00	305.20	0.04129	-13.301	15.676	22.165	22.285
290.00	315.20	0.04204	-13.565	15.677	22.304	22.417
300.00	325.20	0.04259	-13.822	15.677	22.439	22.546
310.00	335.20	0.04298	-14.072	15.678	22.570	22.671
320.00	345.20	0.04326	-14.316	15.678	22.698	22.792
330.00	355.20	0.04343	-14.553	15.678	22.822	22.911
340.00	365.20	0.04350	-14.785	15.678	22.942	23.027
350.00	375.20	0.04350	-15.010	15.678	23.059	23.140
360.00	385.20	0.04341	-15.231	15.678	23.174	23.250
370.00	395.20	0.04326	-15.446	15.678	23.285	23.358
380.00	405.20	0.04309	-15.657	15.678	23.394	23.463
390.00	415.20	0.04289	-15.863	15.678	23.500	23.566
400.00	425.20	0.04262	-16.064	15.677	23.604	23.666

Table 3: Range Correction Data for SA Model 12-1.7

*****LSI***** ((FREQUENCY= 1.970 GHZ))

DE= 6.77 CM DH= 9.98 CM CE= 50.48 CM CH= 46.05 CM

B= 27.30 CM(1.7925 LAMDA) A= 36.85 CM(2.4198 LAMDA)

EL= 35.83 CM(2.3530 LAMDA) HL= 41.93 CM(2.7534 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
5350.30	5367.06	0.00000	-41.625	15.651	36.463	36.463
100.00	116.75	-0.01930	-9.100	15.631	19.858	20.201
110.00	126.75	-0.00147	-9.681	15.649	20.197	20.491
120.00	136.75	0.01133	-10.237	15.662	20.514	20.769
130.00	146.75	0.02063	-10.767	15.671	20.811	21.034
140.00	156.75	0.02742	-11.273	15.678	21.090	21.287
150.00	166.75	0.03240	-11.756	15.683	21.354	21.529
160.00	176.75	0.03605	-12.218	15.687	21.603	21.760
170.00	186.75	0.03868	-12.659	15.689	21.840	21.980
180.00	196.75	0.04056	-13.081	15.691	22.064	22.191
190.00	206.75	0.04187	-13.486	15.693	22.278	22.394
200.00	216.75	0.04275	-13.874	15.693	22.482	22.588
210.00	226.75	0.04328	-14.247	15.694	22.678	22.774
220.00	236.75	0.04355	-14.606	15.694	22.865	22.954
230.00	246.75	0.04360	-14.951	15.694	23.045	23.126
240.00	256.75	0.04352	-15.284	15.694	23.217	23.293
250.00	266.76	0.04328	-15.606	15.694	23.383	23.453
260.00	276.76	0.04298	-15.916	15.694	23.544	23.609
270.00	286.75	0.04261	-16.216	15.693	23.698	23.759
280.00	296.76	0.04211	-16.507	15.693	23.847	23.904
290.00	306.75	0.04165	-16.789	15.692	23.992	24.045
300.00	316.76	0.04112	-17.062	15.692	24.132	24.182
310.00	326.75	0.04058	-17.327	15.691	24.267	24.314
320.00	336.76	0.03999	-17.584	15.691	24.399	24.443
330.00	346.75	0.03941	-17.835	15.690	24.526	24.568
340.00	356.76	0.03882	-18.078	15.690	24.650	24.690
350.00	366.75	0.03825	-18.315	15.689	24.771	24.808
360.00	376.76	0.03765	-18.546	15.688	24.888	24.924
370.00	386.75	0.03706	-18.772	15.688	25.003	25.036
380.00	396.76	0.03648	-18.991	15.687	25.114	25.146
390.00	406.76	0.03591	-19.205	15.687	25.223	25.253
400.00	416.76	0.03534	-19.415	15.686	25.329	25.358

Table 4: Range Correction Data for SA Model 12-2.6

*****LSI***** ((FREQUENCY= 3.000 GHZ))

DE= 8.31 CM DH= 12.11 CM CE= 59.03 CM CH= 54.91 CM

B= 24.00 CM(2.4003 LAMDA) A= 32.41 CM(3.2410 LAMDA)

EL= 42.15 CM(4.2146 LAMDA) HL= 47.45 CM(4.7452 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
6302.60	6323.03	0.00000	-41.884	18.060	39.001	39.002
100.00	120.42	-0.08311	-8.523	17.976	21.882	22.321
110.00	130.42	-0.05708	-9.045	18.002	22.203	22.582
120.00	140.42	-0.03762	-9.551	18.022	22.504	22.835
130.00	150.42	-0.02284	-10.040	18.037	22.788	23.079
140.00	160.42	-0.01146	-10.510	18.048	23.056	23.314
150.00	170.42	-0.00261	-10.961	18.057	23.310	23.540
160.00	180.42	0.00432	-11.396	18.064	23.551	23.757
170.00	190.42	0.00978	-11.813	18.069	23.780	23.966
180.00	200.42	0.01413	-12.214	18.074	23.997	24.166
190.00	210.42	0.01757	-12.599	18.077	24.205	24.359
200.00	220.42	0.02032	-12.971	18.080	24.404	24.545
210.00	230.42	0.02254	-13.329	18.082	24.595	24.724
220.00	240.42	0.02426	-13.674	18.084	24.778	24.896
230.00	250.42	0.02566	-14.007	18.085	24.953	25.063
240.00	260.42	0.02676	-14.328	18.086	25.122	25.224
250.00	270.42	0.02761	-14.640	18.087	25.285	25.379
260.00	280.42	0.02827	-14.941	18.088	25.442	25.530
270.00	290.42	0.02872	-15.232	18.088	25.594	25.676
280.00	300.42	0.02910	-15.515	18.089	25.740	25.817
290.00	310.42	0.02934	-15.790	18.089	25.882	25.954
300.00	320.42	0.02949	-16.056	18.089	26.020	26.088
310.00	330.42	0.02958	-16.315	18.089	26.153	26.217
320.00	340.42	0.02955	-16.566	18.089	26.283	26.343
330.00	350.42	0.02949	-16.811	18.089	26.409	26.465
340.00	360.42	0.02943	-17.050	18.089	26.531	26.584
350.00	370.42	0.02927	-17.282	18.089	26.650	26.701
360.00	380.42	0.02914	-17.509	18.089	26.766	26.814
370.00	390.42	0.02895	-17.730	18.089	26.879	26.924
380.00	400.42	0.02876	-17.945	18.088	26.989	27.032
390.00	410.42	0.02852	-18.156	18.088	27.096	27.137
400.00	420.42	0.02828	-18.361	18.088	27.201	27.240

Table 5: Range Correction Data for Narda Model 644

*****LSI***** ((FREQUENCY= 3.275 GHZ))

DE= 2.96 CM DH= 4.67 CM CE= 33.85 CM CH= 32.74 CM
B= 17.16 CM(1.8733 LAMDA) A= 23.18 CM(2.5305 LAMDA)
EL= 34.27 CM(3.7411 LAMDA) HL= 38.54 CM(4.2073 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
3519.40	3527.02	0.00000	-40.792	16.451	36.847	36.847
100.00	107.63	0.02874	-10.822	16.480	21.663	21.862
110.00	117.63	0.03446	-11.520	16.486	22.044	22.211
120.00	127.63	0.03802	-12.172	16.489	22.394	22.537
130.00	137.63	0.04020	-12.784	16.491	22.720	22.843
140.00	147.63	0.04140	-13.360	16.493	23.023	23.131
150.00	157.63	0.04194	-13.902	16.493	23.307	23.402
160.00	167.63	0.04205	-14.414	16.493	23.574	23.658
170.00	177.63	0.04180	-14.900	16.493	23.826	23.901
180.00	187.63	0.04136	-15.361	16.493	24.065	24.132
190.00	197.63	0.04079	-15.800	16.492	24.291	24.351
200.00	207.63	0.04008	-16.219	16.491	24.506	24.561
210.00	217.63	0.03931	-16.620	16.491	24.711	24.761
220.00	227.63	0.03851	-17.003	16.490	24.907	24.953
230.00	237.63	0.03769	-17.370	16.489	25.094	25.137
240.00	247.63	0.03686	-17.724	16.488	25.274	25.313
250.00	257.63	0.03604	-18.063	16.487	25.447	25.483
260.00	267.63	0.03523	-18.390	16.487	25.613	25.646
270.00	277.63	0.03439	-18.706	16.486	25.773	25.804
280.00	287.63	0.03359	-19.011	16.485	25.928	25.957
290.00	297.63	0.03273	-19.305	16.484	26.077	26.104
300.00	307.63	0.03196	-19.591	16.483	26.221	26.247
310.00	317.63	0.03127	-19.867	16.483	26.361	26.385
320.00	327.63	0.03051	-20.135	16.482	26.496	26.519
330.00	337.63	0.02985	-20.395	16.481	26.628	26.649
340.00	347.63	0.02916	-20.647	16.480	26.755	26.775
350.00	357.63	0.02856	-20.892	16.480	26.879	26.898
360.00	367.63	0.02790	-21.131	16.479	26.999	27.017
370.00	377.63	0.02722	-21.364	16.479	27.116	27.133
380.00	387.63	0.02667	-21.590	16.478	27.230	27.246
390.00	397.63	0.02606	-21.811	16.477	27.342	27.357
400.00	407.63	0.02553	-22.027	16.477	27.450	27.465

Table 6: Range Correction Data for SA Model 12-3.9

*****LSI***** ((FREQUENCY= 4.500 GHZ))

DE= 5.55 CM DH= 8.06 CM CE= 39.35 CM CH= 36.62 CM

B= 16.00 CM(2.4003 LAMDA) A= 21.61 CM(3.2412 LAMDA)

EL= 28.10 CM(4.2146 LAMDA) HL= 31.65 CM(4.7480 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
4202.07	4215.69	0.00000	-41.880	18.062	39.002	39.002
100.00	113.62	-0.00325	-10.959	18.058	23.311	23.541
110.00	123.62	0.00653	-11.603	18.068	23.667	23.863
120.00	133.62	0.01340	-12.211	18.075	23.998	24.167
130.00	143.62	0.01827	-12.784	18.080	24.307	24.454
140.00	153.62	0.02171	-13.326	18.083	24.596	24.725
150.00	163.62	0.02417	-13.839	18.086	24.867	24.981
160.00	173.62	0.02590	-14.326	18.088	25.123	25.225
170.00	183.62	0.02708	-14.789	18.089	25.365	25.456
180.00	193.62	0.02785	-15.230	18.090	25.595	25.677
190.00	203.62	0.02831	-15.651	18.090	25.813	25.887
200.00	213.62	0.02855	-16.054	18.090	26.021	26.088
210.00	223.62	0.02864	-16.439	18.090	26.219	26.281
220.00	233.62	0.02856	-16.809	18.090	26.409	26.466
230.00	243.62	0.02840	-17.164	18.090	26.592	26.644
240.00	253.62	0.02817	-17.506	18.090	26.767	26.815
250.00	263.62	0.02783	-17.836	18.090	26.935	26.980
260.00	273.62	0.02753	-18.153	18.089	27.097	27.138
270.00	283.62	0.02718	-18.460	18.089	27.253	27.292
280.00	293.62	0.02675	-18.757	18.088	27.404	27.440
290.00	303.62	0.02632	-19.044	18.088	27.550	27.584
300.00	313.62	0.02591	-19.322	18.088	27.691	27.723
310.00	323.62	0.02551	-19.592	18.087	27.828	27.858
320.00	333.62	0.02511	-19.853	18.087	27.960	27.988
330.00	343.62	0.02464	-20.108	18.086	28.089	28.116
340.00	353.62	0.02427	-20.355	18.086	28.214	28.239
350.00	363.62	0.02382	-20.595	18.086	28.336	28.359
360.00	373.62	0.02341	-20.829	18.085	28.454	28.476
370.00	383.62	0.02300	-21.057	18.085	28.569	28.590
380.00	393.62	0.02255	-21.279	18.084	28.681	28.701
390.00	403.62	0.02222	-21.496	18.084	28.790	28.810
400.00	413.62	0.02176	-21.708	18.083	28.897	28.915

Table 7: Range Correction Data for Narda Model 642

*****LSI***** ((FREQUENCY= 6.800 GHZ))

DE= 1.42 CM DH= 2.60 CM CE= 16.44 CM CH= 17.56 CM
B= 8.30 CM(1.8813 LAMDA) A= 11.80 CM(2.6747 LAMDA)
EL= 16.86 CM(3.8216 LAMDA) HL= 19.98 CM(4.5288 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
1893.66	1897.69	0.00000	-41.272	16.693	37.328	37.328
100.00	104.02	0.07170	-16.020	16.764	24.646	24.703
110.00	114.02	0.06758	-16.807	16.760	25.048	25.096
120.00	124.02	0.06380	-17.530	16.756	25.417	25.458
130.00	134.02	0.06023	-18.199	16.753	25.758	25.792
140.00	144.02	0.05691	-18.822	16.750	26.073	26.103
150.00	154.02	0.05388	-19.403	16.747	26.368	26.394
160.00	164.02	0.05118	-19.949	16.744	26.644	26.667
170.00	174.02	0.04857	-20.463	16.741	26.903	26.924
180.00	184.02	0.04625	-20.949	16.739	27.148	27.167
190.00	194.02	0.04411	-21.409	16.737	27.380	27.397
200.00	204.02	0.04198	-21.846	16.735	27.601	27.616
210.00	214.02	0.04015	-22.263	16.733	27.810	27.824
220.00	224.02	0.03838	-22.661	16.731	28.011	28.023
230.00	234.02	0.03680	-23.041	16.729	28.202	28.213
240.00	244.02	0.03530	-23.406	16.728	28.385	28.395
250.00	254.02	0.03388	-23.756	16.727	28.561	28.571
260.00	264.02	0.03251	-24.092	16.725	28.730	28.739
270.00	274.02	0.03135	-24.416	16.724	28.892	28.901
280.00	284.02	0.03015	-24.729	16.723	29.049	29.057
290.00	294.02	0.02917	-25.030	16.722	29.201	29.208
300.00	304.02	0.02814	-25.322	16.721	29.347	29.354
310.00	314.02	0.02720	-25.604	16.720	29.488	29.495
320.00	324.02	0.02615	-25.878	16.719	29.626	29.632
330.00	334.02	0.02526	-26.143	16.718	29.758	29.764
340.00	344.02	0.02454	-26.400	16.717	29.887	29.893
350.00	354.02	0.02380	-26.650	16.716	30.012	30.017
360.00	364.02	0.02285	-26.893	16.715	30.134	30.139
370.00	374.02	0.02214	-27.129	16.715	30.253	30.257
380.00	384.02	0.02146	-27.359	16.714	30.368	30.372
390.00	394.02	0.02082	-27.584	16.713	30.480	30.484
400.00	404.02	0.02025	-27.802	16.713	30.590	30.594

Table 8: Range Correction Data for SA Model 12-5.8

*****LSI***** ((FREQUENCY= 6.315 GHZ))
DE= 22.00 CM DH= 29.84 CM CE= 93.58 CM CH= 77.04 CM
B= 21.37 CM(4.4992 LAMDA) A= 28.85 CM(6.0739 LAMDA)
EL= 47.50 CM(9.9983 LAMDA) HL= 50.84 CM(10.7009 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
10515.44	10567.28	0.00000	-44.630	22.149	44.464	44.464
100.00	151.84	-0.37231	-9.719	21.777	26.411	27.009
110.00	161.84	-0.31424	-10.031	21.835	26.630	27.165
120.00	171.84	-0.26760	-10.350	21.882	26.843	27.324
130.00	181.84	-0.22967	-10.672	21.920	27.051	27.485
140.00	191.84	-0.19845	-10.994	21.951	27.252	27.646
150.00	201.84	-0.17249	-11.314	21.977	27.447	27.806
160.00	211.84	-0.15069	-11.629	21.999	27.635	27.964
170.00	221.84	-0.13224	-11.939	22.017	27.817	28.119
180.00	231.84	-0.11649	-12.243	22.033	27.993	28.271
190.00	241.84	-0.10300	-12.540	22.046	28.163	28.419
200.00	251.84	-0.09130	-12.831	22.058	28.327	28.565
210.00	261.84	-0.08118	-13.115	22.068	28.486	28.707
220.00	271.84	-0.07232	-13.393	22.077	28.640	28.845
230.00	281.84	-0.06456	-13.663	22.085	28.789	28.981
240.00	291.84	-0.05773	-13.928	22.092	28.934	29.113
250.00	301.84	-0.05168	-14.186	22.098	29.074	29.242
260.00	311.84	-0.04630	-14.438	22.103	29.210	29.368
270.00	321.84	-0.04150	-14.684	22.108	29.342	29.491
280.00	331.84	-0.03720	-14.924	22.112	29.471	29.611
290.00	341.84	-0.03337	-15.158	22.116	29.596	29.728
300.00	351.84	-0.02992	-15.388	22.119	29.718	29.843
310.00	361.84	-0.02676	-15.611	22.122	29.837	29.955
320.00	371.84	-0.02398	-15.830	22.125	29.952	30.064
330.00	381.84	-0.02143	-16.044	22.128	30.065	30.171
340.00	391.84	-0.01913	-16.254	22.130	30.175	30.276
350.00	401.84	-0.01700	-16.459	22.132	30.282	30.379
360.00	411.84	-0.01511	-16.659	22.134	30.387	30.479
370.00	421.84	-0.01335	-16.856	22.136	30.489	30.577
380.00	431.84	-0.01175	-17.048	22.137	30.590	30.673
390.00	441.84	-0.01033	-17.237	22.139	30.688	30.768
400.00	451.84	-0.00893	-17.422	22.140	30.783	30.860

Table 9: Range Correction Data for SA Model 12-8.2

*****LSI***** ((FREQUENCY= 8.000 GHZ))

DE= 10.60 CM DH= 15.02 CM CE= 55.13 CM CH= 48.45 CM
B= 14.40 CM(3.8400 LAMDA) A= 19.44 CM(5.1840 LAMDA)
EL= 32.00 CM(8.5333 LAMDA) HL= 34.25 CM(9.1333 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
6046.62	6072.23	0.00000	-43.363	21.404	43.085	43.085
100.00	125.61	-0.12242	-10.605	21.281	26.365	26.706
110.00	135.61	-0.09755	-11.130	21.306	26.672	26.969
120.00	145.61	-0.07843	-11.636	21.325	26.962	27.222
130.00	155.61	-0.06341	-12.121	21.340	27.236	27.465
140.00	165.61	-0.05150	-12.587	21.352	27.494	27.698
150.00	175.61	-0.04189	-13.034	21.362	27.739	27.921
160.00	185.61	-0.03411	-13.463	21.370	27.972	28.135
170.00	195.61	-0.02771	-13.875	21.376	28.194	28.341
180.00	205.61	-0.02237	-14.270	21.381	28.405	28.539
190.00	215.61	-0.01794	-14.650	21.386	28.606	28.729
200.00	225.61	-0.01419	-15.016	21.390	28.800	28.912
210.00	235.61	-0.01105	-15.368	21.393	28.985	29.088
220.00	245.61	-0.00837	-15.707	21.395	29.163	29.258
230.00	255.61	-0.00611	-16.035	21.398	29.334	29.421
240.00	265.61	-0.00410	-16.352	21.400	29.498	29.580
250.00	275.61	-0.00248	-16.658	21.401	29.657	29.733
260.00	285.61	-0.00100	-16.955	21.403	29.811	29.881
270.00	295.61	0.00031	-17.242	21.404	29.959	30.025
280.00	305.61	0.00143	-17.520	21.405	30.102	30.164
290.00	315.61	0.00231	-17.790	21.406	30.241	30.299
300.00	325.61	0.00320	-18.053	21.407	30.376	30.430
310.00	335.61	0.00390	-18.308	21.408	30.506	30.558
320.00	345.61	0.00456	-18.556	21.408	30.633	30.682
330.00	355.61	0.00505	-18.797	21.409	30.757	30.802
340.00	365.61	0.00562	-19.032	21.409	30.876	30.920
350.00	375.61	0.00603	-19.261	21.410	30.993	31.034
360.00	385.61	0.00640	-19.484	21.410	31.107	31.146
370.00	395.61	0.00667	-19.702	21.410	31.218	31.255
380.00	405.61	0.00698	-19.915	21.411	31.326	31.361
390.00	415.61	0.00726	-20.122	21.411	31.431	31.465
400.00	425.61	0.00742	-20.326	21.411	31.535	31.567

Table 10: Range Correction Data for SA Model 12-8.2

*****LSI***** ((FREQUENCY= 9.000 GHZ))

DE= 13.60 CM DH= 18.68 CM CE= 60.97 CM CH= 51.19 CM
B= 14.40 CM(4.3200 LAMDA) A= 19.44 CM(5.8320 LAMDA)
EL= 32.00 CM(9.6000 LAMDA) HL= 34.25 CM(10.2750 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
6802.44	6834.73	0.00000	-44.264	21.979	44.111	44.111
100.00	132.28	-0.16303	-11.047	21.816	27.141	27.502
110.00	142.28	-0.13296	-11.529	21.846	27.428	27.743
120.00	152.28	-0.10954	-11.997	21.869	27.699	27.977
130.00	162.28	-0.09096	-12.449	21.888	27.957	28.203
140.00	172.28	-0.07605	-12.886	21.903	28.202	28.422
150.00	182.28	-0.06392	-13.307	21.915	28.435	28.632
160.00	192.28	-0.05393	-13.713	21.925	28.657	28.835
170.00	202.28	-0.04568	-14.103	21.933	28.869	29.030
180.00	212.28	-0.03874	-14.480	21.940	29.071	29.219
190.00	222.28	-0.03292	-14.843	21.946	29.265	29.400
200.00	232.28	-0.02796	-15.193	21.951	29.451	29.575
210.00	242.28	-0.02372	-15.531	21.955	29.630	29.744
220.00	252.28	-0.02010	-15.858	21.959	29.802	29.908
230.00	262.28	-0.01696	-16.174	21.962	29.968	30.066
240.00	272.28	-0.01429	-16.480	21.964	30.128	30.219
250.00	282.28	-0.01190	-16.776	21.967	30.282	30.367
260.00	292.28	-0.00987	-17.063	21.969	30.431	30.510
270.00	302.28	-0.00807	-17.342	21.971	30.576	30.649
280.00	312.28	-0.00647	-17.612	21.972	30.715	30.785
290.00	322.28	-0.00505	-17.875	21.974	30.851	30.916
300.00	332.28	-0.00380	-18.130	21.975	30.982	31.044
310.00	342.28	-0.00272	-18.378	21.976	31.110	31.168
320.00	352.28	-0.00176	-18.620	21.977	31.234	31.289
330.00	362.28	-0.00094	-18.856	21.978	31.355	31.407
340.00	372.28	-0.00011	-19.085	21.979	31.472	31.521
350.00	382.28	0.00049	-19.309	21.979	31.587	31.633
360.00	392.28	0.00119	-19.527	21.980	31.698	31.742
370.00	402.28	0.00166	-19.741	21.980	31.807	31.849
380.00	412.28	0.00212	-19.949	21.981	31.913	31.953
390.00	422.28	0.00265	-20.153	21.981	32.017	32.055
400.00	432.28	0.00299	-20.352	21.982	32.118	32.155

Table 11: Range Correction Data for SA Model 12-8.2

*****LSI***** ((FREQUENCY= 10.000 GHZ))

S= 16.98 CM DH= 22.55 CM CE= 66.39 CM CH= 52.71 CM

B= 14.40 CM(4.8000 LAMDA) A= 19.44 CM(6.4800 LAMDA)

L= 32.00 CM(10.6667 LAMDA) HL= 34.25 CM(11.4167 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
7558.27	7597.81	0.00000	-45.261	22.397	45.028	45.033
100.00	139.54	-0.20558	-11.685	22.192	27.873	28.240
110.00	149.54	-0.17060	-12.128	22.227	28.139	28.461
120.00	159.54	-0.14298	-12.562	22.254	28.392	28.678
130.00	169.54	-0.12085	-12.984	22.276	28.634	28.88[illegible]
140.00	179.54	-0.10289	-13.394	22.294	28.865	29.09[illegible]
150.00	189.54	-0.08814	-13.790	22.309	29.086	29.29[illegible]
160.00	199.54	-0.07591	-14.174	22.321	29.297	29.48[illegible]
170.00	209.54	-0.06567	-14.545	22.332	29.499	29.679
180.00	219.54	-0.05704	-14.903	22.340	29.693	29.849
190.00	229.54	-0.04971	-15.250	22.348	29.879	30.022
200.00	239.54	-0.04345	-15.585	22.354	30.058	30.190
210.00	249.54	-0.03805	-15.909	22.359	30.230	30.352
220.00	259.54	-0.03336	-16.223	22.364	30.396	30.509
230.00	269.54	-0.02930	-16.527	22.368	30.556	30.661
240.00	279.54	-0.02579	-16.822	22.372	30.711	30.809
250.00	289.54	-0.02265	-17.109	22.375	30.861	30.952
260.00	299.54	-0.01992	-17.386	22.377	31.005	31.090
270.00	309.54	-0.01753	-17.656	22.380	31.146	31.225
280.00	319.54	-0.01536	-17.918	22.382	31.281	31.356
290.00	329.54	-0.01346	-18.173	22.384	31.413	31.484
300.00	339.54	-0.01175	-18.422	22.386	31.542	31.608
310.00	349.54	-0.01028	-18.663	22.387	31.666	31.729
320.00	359.54	-0.00892	-18.899	22.388	31.787	31.847
330.00	369.54	-0.00769	-19.128	22.390	31.905	31.962
340.00	379.54	-0.00660	-19.352	22.391	32.020	32.073
350.00	389.54	-0.00561	-19.571	22.392	32.132	32.183
360.00	399.54	-0.00474	-19.784	22.393	32.241	32.293
370.00	409.54	-0.00398	-19.993	22.393	32.348	32.394
380.00	419.54	-0.00320	-20.197	22.394	32.452	32.496
390.00	429.54	-0.00248	-20.396	22.395	32.553	32.595
400.00	439.54	-0.00202	-20.591	22.395	32.653	32.693

Table 12: Range Correction Data for SA Model 12-8.2

*****LSI***** (FREQUENCY= 11.000 GHZ)

DE= 20.80 CM DH= 26.55 CM CE= 71.32 CM CH= 52.91 CM
B= 14.40 CM(5.2800 LAMDA) A= 19.44 CM(7.1280 LAMDA)
LL= 32.00 CM(11.7333 LAMDA) HL= 34.25 CM(12.5583 LAMDA)

ZAA (CM)	R (CM)	PGAN DB	PRPT DB	NFGAIN DB	PGU DB	PGC DB
8314.10	8361.45	0.00000	-46.354	22.681	45.858	45.858
100.00	147.35	-0.24572	-12.486	22.435	28.564	28.924
110.00	157.35	-0.20647	-12.896	22.475	28.810	29.129
120.00	167.35	-0.17514	-13.300	22.506	29.046	29.331
130.00	177.35	-0.14976	-13.694	22.531	29.273	29.528
140.00	187.35	-0.12898	-14.079	22.552	29.490	29.721
150.00	197.35	-0.11175	-14.453	22.569	29.699	29.909
160.00	207.35	-0.09735	-14.816	22.584	29.899	30.093
170.00	217.35	-0.08519	-15.168	22.596	30.092	30.272
180.00	227.35	-0.07489	-15.510	22.606	30.277	30.436
190.00	237.35	-0.06606	-15.841	22.615	30.455	30.601
200.00	247.35	-0.05844	-16.161	22.623	30.626	30.762
210.00	257.35	-0.05188	-16.472	22.629	30.792	30.917
220.00	267.35	-0.04613	-16.774	22.635	30.952	31.068
230.00	277.35	-0.04113	-17.067	22.640	31.106	31.215
240.00	287.35	-0.03669	-17.351	22.644	31.256	31.357
250.00	297.35	-0.03282	-17.628	22.648	31.400	31.495
260.00	307.35	-0.02941	-17.896	22.652	31.541	31.629
270.00	317.35	-0.02633	-18.158	22.655	31.677	31.760
280.00	327.35	-0.02362	-18.412	22.657	31.809	31.887
290.00	337.35	-0.02115	-18.659	22.660	31.937	32.011
300.00	347.35	-0.01898	-18.900	22.662	32.061	32.131
310.00	357.35	-0.01701	-19.135	22.664	32.183	32.249
320.00	367.35	-0.01526	-19.365	22.666	32.301	32.363
330.00	377.35	-0.01369	-19.588	22.667	32.416	32.475
340.00	387.35	-0.01229	-19.807	22.669	32.528	32.584
350.00	397.35	-0.01100	-20.020	22.670	32.638	32.691
360.00	407.35	-0.00987	-20.228	22.671	32.744	32.795
370.00	417.35	-0.00867	-20.432	22.672	32.848	32.897
380.00	427.35	-0.00775	-20.632	22.673	32.950	32.997
390.00	437.35	-0.00683	-20.826	22.674	33.050	33.094
400.00	447.35	-0.00596	-21.017	22.675	33.147	33.190

Table 13: Range Correction Data for SA Model 12-8.2

*****LSI***** ((FREQUENCY= 12.000 GHZ))

DE= 25.06 CM DH= 30.51 CM CE= 75.64 CM CH= 51.67 CM
B= 14.40 CM(5.7600 LAMDA) A= 19.44 CM(7.7760 LAMDA)
EL= 32.00 CM(12.8000 LAMDA) HL= 34.25 CM(13.7000 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
9069.93	9125.50	0.00000	-47.537	22.847	46.615	46.615
100.00	155.57	-0.28329	-13.425	22.564	29.215	29.559
110.00	165.57	-0.24057	-13.806	22.606	29.443	29.750
120.00	175.57	-0.20608	-14.183	22.641	29.663	29.938
130.00	185.57	-0.17787	-14.553	22.669	29.876	30.124
140.00	195.57	-0.15454	-14.916	22.692	30.080	30.305
150.00	205.57	-0.13506	-15.270	22.712	30.277	30.482
160.00	215.57	-0.11864	-15.614	22.728	30.467	30.654
170.00	225.57	-0.10468	-15.949	22.742	30.650	30.821
180.00	235.57	-0.09276	-16.275	22.754	30.827	30.984
190.00	245.57	-0.08247	-16.591	22.764	30.997	31.142
200.00	255.57	-0.07357	-16.898	22.773	31.161	31.296
210.00	265.57	-0.06582	-17.197	22.781	31.320	31.445
220.00	275.57	-0.05901	-17.487	22.788	31.474	31.590
230.00	285.57	-0.05305	-17.769	22.794	31.623	31.731
240.00	295.57	-0.04776	-18.043	22.799	31.767	31.869
250.00	305.57	-0.04308	-18.310	22.804	31.907	32.002
260.00	315.57	-0.03892	-18.570	22.808	32.043	32.132
270.00	325.57	-0.03518	-18.823	22.812	32.174	32.258
280.00	335.57	-0.03187	-19.069	22.815	32.302	32.382
290.00	345.57	-0.02887	-19.310	22.818	32.427	32.502
300.00	355.57	-0.02612	-19.544	22.821	32.548	32.619
310.00	365.57	-0.02366	-19.772	22.823	32.666	32.733
320.00	375.57	-0.02152	-19.995	22.825	32.781	32.845
330.00	385.57	-0.01948	-20.213	22.827	32.893	32.954
340.00	395.57	-0.01767	-20.426	22.829	33.003	33.060
350.00	405.57	-0.01602	-20.634	22.831	33.109	33.164
360.00	415.57	-0.01449	-20.837	22.832	33.214	33.266
370.00	425.57	-0.01309	-21.036	22.834	33.316	33.365
380.00	435.57	-0.01183	-21.231	22.835	33.415	33.463
390.00	445.57	-0.01067	-21.422	22.836	33.513	33.558
400.00	455.57	-0.00959	-21.609	22.837	33.608	33.651

Table 14: Range Correction Data for Narda Model 640

*****LSI***** ((FREQUENCY= 8.000 GHZ))

DE= 0.65 CM DH= 0.99 CM CE= 10.07 CM CH= 9.42 CM
B= 5.95 CM(1.5867 LAMDA) A= 7.86 CM(2.0960 LAMDA)
EL= 12.75 CM(3.4000 LAMDA) HL= 14.25 CM(3.8000 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
988.47	990.11	0.00000	-40.197	15.110	35.209	35.209
100.00	101.64	0.03480	-20.394	15.145	25.287	25.307
110.00	111.64	0.03223	-21.208	15.143	25.698	25.714
120.00	121.64	0.02992	-21.952	15.140	26.073	26.086
130.00	131.64	0.02782	-22.639	15.138	26.418	26.430
140.00	141.64	0.02607	-23.275	15.136	26.737	26.748
150.00	151.64	0.02436	-23.868	15.135	27.035	27.044
160.00	161.64	0.02281	-24.424	15.133	27.314	27.322
170.00	171.64	0.02151	-24.946	15.132	27.576	27.583
180.00	181.64	0.02030	-25.439	15.131	27.824	27.830
190.00	191.64	0.01913	-25.905	15.129	28.057	28.063
200.00	201.64	0.01805	-26.348	15.128	28.279	28.285
210.00	211.64	0.01712	-26.770	15.127	28.491	28.495
220.00	221.64	0.01629	-27.172	15.127	28.692	28.696
230.00	231.64	0.01544	-27.556	15.126	28.884	28.888
240.00	241.64	0.01450	-27.924	15.125	29.069	29.072
250.00	251.64	0.01396	-28.277	15.124	29.246	29.249
260.00	261.64	0.01322	-28.616	15.124	29.416	29.419
270.00	271.64	0.01259	-28.943	15.123	29.579	29.582
280.00	281.64	0.01209	-29.258	15.122	29.737	29.739
290.00	291.64	0.01155	-29.561	15.122	29.889	29.891
300.00	301.64	0.01096	-29.855	15.121	30.036	30.038
310.00	311.64	0.01037	-30.139	15.121	30.178	30.180
320.00	321.64	0.01005	-30.414	15.120	30.315	30.317
330.00	331.64	0.00952	-30.681	15.120	30.449	30.451
340.00	341.64	0.00904	-30.940	15.119	30.578	30.580
350.00	351.64	0.00864	-31.191	15.119	30.704	30.706
360.00	361.64	0.00835	-31.435	15.119	30.826	30.828
370.00	371.64	0.00815	-31.672	15.118	30.945	30.946
380.00	381.64	0.00781	-31.903	15.118	31.060	31.062
390.00	391.64	0.00735	-32.129	15.118	31.173	31.175
400.00	401.64	0.00728	-32.348	15.118	31.283	31.284

Table 15: Range Correction Data for Narda Model 640

*****LSI***** ((FREQUENCY= 9.000 GHZ))

DE= 0.85 CM DH= 1.26 CM CE= 11.24 CM CH= 10.51 CM

B= 5.95 CM(1.7850 LAMDA) A= 7.86 CM(2.3580 LAMDA)

EL= 12.75 CM(3.8250 LAMDA) HL= 14.25 CM(4.2750 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
1112.03	1114.14	0.00000	-40.369	16.048	36.233	36.233
100.00	102.11	0.03435	-19.591	16.083	25.819	25.844
110.00	112.11	0.03199	-20.399	16.080	26.228	26.248
120.00	122.11	0.02982	-21.139	16.078	26.601	26.618
130.00	132.11	0.02791	-21.822	16.076	26.945	26.959
140.00	142.11	0.02620	-22.455	16.075	27.263	27.276
150.00	152.11	0.02464	-23.046	16.073	27.560	27.571
160.00	162.11	0.02320	-23.599	16.072	27.838	27.848
170.00	172.11	0.02193	-24.119	16.070	28.099	28.108
180.00	182.11	0.02066	-24.610	16.069	28.346	28.354
190.00	192.11	0.01963	-25.075	16.068	28.579	28.586
200.00	202.11	0.01857	-25.517	16.067	28.801	28.807
210.00	212.11	0.01764	-25.937	16.066	29.011	29.017
220.00	222.11	0.01662	-26.338	16.065	29.212	29.218
230.00	232.11	0.01584	-26.721	16.064	29.404	29.409
240.00	242.11	0.01516	-27.088	16.064	29.588	29.593
250.00	252.11	0.01441	-27.441	16.063	29.765	29.769
260.00	262.11	0.01365	-27.780	16.062	29.934	29.938
270.00	272.11	0.01319	-28.105	16.062	30.098	30.101
280.00	282.11	0.01259	-28.419	16.061	30.255	30.258
290.00	292.11	0.01212	-28.722	16.061	30.407	30.410
300.00	302.11	0.01159	-29.015	16.060	30.553	30.556
310.00	312.11	0.01102	-29.299	16.059	30.695	30.698
320.00	322.11	0.01068	-29.573	16.059	30.833	30.835
330.00	332.11	0.01035	-29.839	16.059	30.966	30.968
340.00	342.11	0.00980	-30.098	16.058	31.093	31.097
350.00	352.11	0.00955	-30.348	16.058	31.220	31.223
360.00	362.11	0.00913	-30.592	16.058	31.343	31.344
370.00	372.11	0.00879	-30.829	16.057	31.461	31.463
380.00	382.11	0.00853	-31.060	16.057	31.577	31.578
390.00	392.11	0.00815	-31.285	16.057	31.689	31.691
400.00	402.11	0.00787	-31.504	16.056	31.799	31.800

Table 16: Range Correction Data for Narda Model 640

*****LSI***** ((FREQUENCY= 10.000 GHZ))

WE= 1.08 CM DH= 1.55 CM CE= 12.41 CM CH= 11.59 CM

B= 5.95 CM(1.9833 LAMDA) A= 7.86 CM(2.6200 LAMDA)

EL= 12.75 CM(4.2500 LAMDA) HL= 14.25 CM(4.7500 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
1235.59	1238.22	0.00000	-40.556	16.871	37.149	37.149
100.00	102.63	0.03343	-18.917	16.905	26.300	26.330
110.00	112.63	0.03132	-19.719	16.903	26.706	26.730
120.00	122.63	0.02941	-20.454	16.901	27.077	27.098
130.00	132.63	0.02780	-21.132	16.899	27.420	27.43
140.00	142.63	0.02601	-21.762	16.897	27.737	27.752
150.00	152.63	0.02450	-22.350	16.896	28.033	28.04
160.00	162.63	0.02319	-22.900	16.894	28.310	28.321
170.00	172.63	0.02193	-23.419	16.893	28.570	28.580
180.00	182.63	0.02073	-23.908	16.892	28.816	28.825
190.00	192.63	0.01973	-24.371	16.891	29.048	29.057
200.00	202.63	0.01880	-24.811	16.890	29.269	29.277
210.00	212.63	0.01800	-25.230	16.889	29.479	29.486
220.00	222.63	0.01702	-25.629	16.888	29.680	29.686
230.00	232.63	0.01641	-26.011	16.888	29.871	29.87
240.00	242.63	0.01561	-26.378	16.887	30.055	30.06
250.00	252.63	0.01492	-26.729	16.886	30.231	30.23
260.00	262.63	0.01438	-27.066	16.886	30.400	30.4
270.00	272.63	0.01385	-27.391	16.885	30.563	30.5
280.00	282.63	0.01315	-27.705	16.884	30.720	30.724
290.00	292.63	0.01254	-28.008	16.884	30.871	30.875
300.00	302.63	0.01206	-28.300	16.883	31.018	31.021
310.00	312.63	0.01173	-28.583	16.883	31.159	31.163
320.00	322.63	0.01114	-28.857	16.882	31.297	31.300
330.00	332.63	0.01077	-29.123	16.882	31.430	31.433
340.00	342.63	0.01040	-29.380	16.882	31.559	31.561
350.00	352.63	0.01004	-29.631	16.881	31.684	31.687
360.00	362.63	0.00975	-29.874	16.881	31.806	31.808
370.00	372.63	0.00950	-30.110	16.881	31.924	31.926
380.00	382.63	0.00910	-30.341	16.880	32.040	32.042
390.00	392.63	0.00857	-30.566	16.880	32.152	32.154
400.00	402.63	0.00834	-30.785	16.880	32.262	32.263

Table 17: Range Correction Data for Narda Model 640

*****LSI***** ((FREQUENCY= 11.000 GHZ))

DE= 1.34 CM DH= 1.88 CM CE= 13.56 CM CH= 12.63 CM

B= 5.95 CM(2.1817 LAMDA) A= 7.86 CM(2.8820 LAMDA)

[illegible]= 12.75 CM(4.6750 LAMDA) HL= 14.25 CM(5.2250 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
1359.15	1362.37	0.00000	-40.758	17.599	37.978	37.978
100.00	103.22	0.03289	-18.350	17.632	26.740	26.774
110.00	113.22	0.03103	-19.146	17.630	27.143	27.172
120.00	123.22	0.02930	-19.875	17.628	27.512	27.537
130.00	133.22	0.02772	-20.549	17.627	27.853	27.874
140.00	143.22	0.02611	-21.176	17.625	28.169	28.187
150.00	153.22	0.02471	-21.760	17.624	28.463	28.479
160.00	163.22	0.02347	-22.308	17.622	28.739	28.753
170.00	173.22	0.02231	-22.824	17.621	28.998	29.011
180.00	183.22	0.02125	-23.311	17.620	29.243	29.254
190.00	193.22	0.02024	-23.772	17.619	29.475	29.485
200.00	203.22	0.01930	-24.210	17.618	29.695	29.704
210.00	213.22	0.01840	-24.628	17.617	29.905	29.913
220.00	223.22	0.01765	-25.026	17.617	30.104	30.112
230.00	233.22	0.01678	-25.407	17.616	30.296	30.303
240.00	243.22	0.01606	-25.772	17.615	30.479	30.485
250.00	253.22	0.01539	-26.122	17.614	30.654	30.660
260.00	263.22	0.01464	-26.459	17.614	30.823	30.829
270.00	273.22	0.01404	-26.784	17.613	30.986	30.991
280.00	283.22	0.01365	-27.096	17.613	31.142	31.147
290.00	293.22	0.01311	-27.398	17.612	31.294	31.298
300.00	303.22	0.01266	-27.690	17.612	31.440	31.444
310.00	313.22	0.01212	-27.972	17.611	31.581	31.585
320.00	323.22	0.01172	-28.245	17.611	31.718	31.722
330.00	333.22	0.01130	-28.510	17.610	31.851	31.854
340.00	343.22	0.01086	-28.768	17.610	31.980	31.983
350.00	353.22	0.01023	-29.018	17.609	32.105	32.108
360.00	363.22	0.01002	-29.261	17.609	32.226	32.229
370.00	373.22	0.00965	-29.497	17.609	32.345	32.347
380.00	383.22	0.00912	-29.727	17.608	32.460	32.463
390.00	393.22	0.00886	-29.951	17.608	32.572	32.575
400.00	403.22	0.00887	-30.169	17.608	32.681	32.684

Table 18: Range Correction Data for Narda Model 640

*****LSI***** ((FREQUENCY= 12.000 GHZ))

DE= 1.63 CM DH= 2.24 CM CE= 14.70 CM CH= 13.63 CM
B= 5.95 CM(2.3800 LAMDA) A= 7.86 CM(3.1440 LAMDA)
EL= 12.75 CM(5.1000 LAMDA) HL= 14.25 CM(5.7000 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
1482.71	1486.58	0.00000	-40.977	18.246	38.735	38.735
100.00	103.87	0.03280	-17.877	18.279	27.145	27.185
110.00	113.87	0.03128	-18.665	18.277	27.545	27.579
120.00	123.87	0.02972	-19.389	18.276	27.912	27.941
130.00	133.87	0.02818	-20.059	18.274	28.251	28.275
140.00	143.87	0.02675	-20.681	18.273	28.566	28.586
150.00	153.87	0.02545	-21.262	18.271	28.859	28.877
160.00	163.87	0.02428	-21.807	18.270	29.133	29.149
170.00	173.87	0.02320	-22.320	18.269	29.392	29.406
180.00	183.87	0.02217	-22.805	18.268	29.636	29.648
190.00	193.87	0.02126	-23.264	18.267	29.866	29.878
200.00	203.87	0.02032	-23.700	18.266	30.086	30.096
210.00	213.87	0.01950	-24.116	18.266	30.295	30.304
220.00	223.87	0.01858	-24.513	18.265	30.494	30.503
230.00	233.87	0.01785	-24.893	18.264	30.685	30.692
240.00	243.87	0.01722	-25.257	18.263	30.867	30.874
250.00	253.87	0.01658	-25.606	18.263	31.042	31.049
260.00	263.87	0.01599	-25.942	18.262	31.211	31.217
270.00	273.87	0.01534	-26.265	18.261	31.373	31.379
280.00	283.87	0.01484	-26.577	18.261	31.529	31.534
290.00	293.87	0.01418	-26.878	18.260	31.680	31.685
300.00	303.87	0.01375	-27.169	18.260	31.826	31.830
310.00	313.87	0.01342	-27.450	18.259	31.967	31.971
320.00	323.87	0.01263	-27.724	18.259	32.104	32.108
330.00	333.87	0.01216	-27.988	18.258	32.236	32.240
340.00	343.87	0.01185	-28.245	18.258	32.365	32.368
350.00	353.87	0.01171	-28.494	18.258	32.489	32.493
360.00	363.87	0.01140	-28.736	18.257	32.611	32.614
370.00	373.87	0.01092	-28.972	18.257	32.729	32.732
380.00	383.87	0.01066	-29.202	18.257	32.844	32.847
390.00	393.87	0.01026	-29.425	18.256	32.956	32.959
400.00	403.87	0.00973	-29.644	18.256	33.065	33.068

Table 19: Range Correction Data for Larda Model CX-20

*****API***** ((FREQUENCY= 8.000 GHZ))
DE= 3.81CM DH= 4.20 CM CE= 23.63 CM CH= 23.24 CM
B= 12.65 CM A= 12.65 CM EL= 22.60 CM HL= 24.84 CM

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
2560.36	2568.38	0.00000	-40.767	18.965	39.348	39.349
100.00	108.02	-0.04704	-13.537	18.918	25.634	25.734
110.00	118.02	-0.03959	-14.259	18.925	26.011	26.095
120.00	128.02	-0.03382	-14.930	18.931	26.358	26.430
130.00	138.02	-0.02927	-15.554	18.936	26.680	26.742
140.00	148.02	-0.02560	-16.138	18.939	26.980	27.034
150.00	158.02	-0.02260	-16.687	18.942	27.261	27.309
160.00	168.02	-0.02012	-17.204	18.945	27.525	27.567
170.00	178.02	-0.01804	-17.693	18.947	27.774	27.812
180.00	188.02	-0.01628	-18.157	18.949	28.010	28.043
190.00	198.02	-0.01477	-18.597	18.950	28.234	28.264
200.00	208.02	-0.01348	-19.017	18.952	28.446	28.474
210.00	218.02	-0.01235	-19.418	18.953	28.649	28.674
220.00	228.02	-0.01137	-19.801	18.954	28.843	28.866
230.00	238.02	-0.01050	-20.169	18.955	29.028	29.049
240.00	248.02	-0.00973	-20.521	18.955	29.206	29.226
250.00	258.02	-0.00905	-20.860	18.956	29.377	29.395
260.00	268.02	-0.00844	-21.187	18.957	29.542	29.558
270.00	278.02	-0.00789	-21.501	18.957	29.700	29.716
280.00	288.02	-0.00740	-21.805	18.958	29.853	29.868
290.00	298.02	-0.00695	-22.099	18.958	30.001	30.015
300.00	308.02	-0.00654	-22.383	18.958	30.144	30.157
310.00	318.02	-0.00618	-22.658	18.959	30.282	30.294
320.00	328.02	-0.00584	-22.925	18.959	30.417	30.428
330.00	338.02	-0.00553	-23.184	18.959	30.547	30.557
340.00	348.02	-0.00525	-23.436	18.960	30.673	30.683
350.00	358.02	-0.00499	-23.680	18.960	30.796	30.805
360.00	368.02	-0.00474	-23.918	18.960	30.915	30.924
370.00	378.02	-0.00452	-24.149	18.961	31.031	31.040
380.00	388.02	-0.00431	-24.375	18.961	31.145	31.152
390.00	398.02	-0.00412	-24.595	18.961	31.255	31.262
400.00	408.02	-0.00393	-24.809	18.961	31.362	31.370

Table 20: Range Correction Data for Larda Model CX-20

*****API***** ((FREQUENCY= 9.000 GHZ))
DE= 4.82CM DH= 5.29 CM CE= 26.13 CM CH= 25.58 CM
B= 12.65 CM A= 12.65 CM EL= 22.60 CM HL= 24.84 CM

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
2880.41	2890.51	0.00000	-41.180	19.783	40.373	40.373
100.00	110.11	-0.05865	-13.147	19.724	26.240	26.357
110.00	120.11	-0.04941	-13.848	19.734	26.608	26.707
120.00	130.11	-0.04225	-14.499	19.741	26.949	27.033
130.00	140.11	-0.03658	-15.108	19.746	27.264	27.337
140.00	150.11	-0.03200	-15.680	19.751	27.559	27.623
150.00	160.11	-0.02826	-16.217	19.755	27.836	27.892
160.00	170.11	-0.02517	-16.725	19.758	28.096	28.145
170.00	180.11	-0.02257	-17.205	19.760	28.341	28.385
180.00	190.11	-0.02036	-17.661	19.763	28.574	28.613
190.00	200.11	-0.01848	-18.095	19.765	28.794	28.830
200.00	210.11	-0.01685	-18.508	19.766	29.005	29.037
210.00	220.11	-0.01544	-18.904	19.768	29.205	29.235
220.00	230.11	-0.01421	-19.282	19.769	29.397	29.424
230.00	240.11	-0.01312	-19.645	19.770	29.580	29.606
240.00	250.11	-0.01216	-19.994	19.771	29.757	29.780
250.00	260.11	-0.01131	-20.329	19.772	29.926	29.947
260.00	270.11	-0.01054	-20.652	19.772	30.089	30.109
270.00	280.11	-0.00986	-20.964	19.773	30.246	30.265
280.00	290.11	-0.00924	-21.265	19.774	30.398	30.415
290.00	300.11	-0.00868	-21.556	19.774	30.545	30.561
300.00	310.11	-0.00817	-21.837	19.775	30.687	30.702
310.00	320.11	-0.00771	-22.110	19.775	30.824	30.838
320.00	330.11	-0.00729	-22.375	19.776	30.957	30.970
330.00	340.11	-0.00690	-22.632	19.776	31.086	31.099
340.00	350.11	-0.00655	-22.881	19.776	31.212	31.224
350.00	360.11	-0.00622	-23.124	19.777	31.334	31.345
360.00	370.11	-0.00592	-23.360	19.777	31.452	31.463
370.00	380.11	-0.00564	-23.590	19.777	31.568	31.578
380.00	390.11	-0.00538	-23.814	19.778	31.681	31.690
390.00	400.11	-0.00514	-24.033	19.778	31.790	31.799
400.00	410.11	-0.00491	-24.246	19.778	31.897	31.906

Table 21: Range Correction Data for Larda Model CX-20

*****API***** ((FREQUENCY= 10.000 GHZ))
DE= 5.94CM DH= 6.50 CM CE= 28.46 CM CH= 27.23 CM
B= 12.65 CM A= 12.65 CM EL= 22.60 CM HL= 24.84 CM

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
3200.45	3212.89	0.00000	-41.639	20.470	41.290	41.299
100.00	112.44	-0.07020	-12.923	20.400	26.800	26.932
110.00	122.44	-0.05916	-13.601	20.411	27.159	27.271
120.00	132.44	-0.05058	-14.234	20.420	27.492	27.587
130.00	142.44	-0.04378	-14.827	20.427	27.801	27.884
140.00	152.44	-0.03829	-15.385	20.432	28.090	28.163
150.00	162.44	-0.03379	-15.911	20.437	28.362	28.426
160.00	172.44	-0.03006	-16.408	20.440	28.617	28.674
170.00	182.44	-0.02693	-16.879	20.443	28.859	28.910
180.00	192.44	-0.02428	-17.327	20.446	29.088	29.134
190.00	202.44	-0.02202	-17.754	20.448	29.306	29.347
200.00	212.44	-0.02006	-18.161	20.450	29.513	29.551
210.00	222.44	-0.01836	-18.551	20.452	29.711	29.746
220.00	232.44	-0.01688	-18.924	20.453	29.901	29.932
230.00	242.44	-0.01557	-19.282	20.455	30.083	30.112
240.00	252.44	-0.01442	-19.627	20.456	30.257	30.284
250.00	262.44	-0.01339	-19.958	20.457	30.425	30.449
260.00	272.44	-0.01247	-20.277	20.458	30.586	30.609
270.00	282.44	-0.01165	-20.586	20.459	30.742	30.763
280.00	292.44	-0.01091	-20.884	20.459	30.892	30.912
290.00	302.44	-0.01024	-21.172	20.460	31.038	31.056
300.00	312.44	-0.00963	-21.451	20.461	31.178	31.196
310.00	322.44	-0.00907	-21.721	20.461	31.314	31.331
320.00	332.44	-0.00857	-21.983	20.462	31.447	31.462
330.00	342.44	-0.00811	-22.238	20.462	31.575	31.589
340.00	352.44	-0.00768	-22.486	20.463	31.699	31.713
350.00	362.44	-0.00729	-22.726	20.463	31.821	31.834
360.00	372.44	-0.00693	-22.961	20.463	31.938	31.951
370.00	382.44	-0.00660	-23.189	20.464	32.053	32.065
380.00	392.44	-0.00629	-23.411	20.464	32.165	32.176
390.00	402.44	-0.00600	-23.628	20.464	32.274	32.284
400.00	412.44	-0.00573	-23.840	20.465	32.380	32.390

Table 22: Range Correction Data for Larda Model CX-20

*****API***** ((FREQUENCY= 11.000 GHZ))
DE= 7.15CM DH= 7.81 CM CE= 30.60 CM CH= 29.65 CM
B= 12.65 CM A= 12.65 CM EL= 22.60 CM HL= 24.84 CM

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
3520.49	3535.45	0.00000	-42.142	21.048	42.119	42.119
100.00	114.96	-0.08356	-12.840	20.965	27.324	27.468
110.00	124.96	-0.07056	-13.495	20.978	27.673	27.796
120.00	134.96	-0.06042	-14.109	20.988	27.997	28.103
130.00	144.96	-0.05235	-14.686	20.996	28.300	28.391
140.00	154.96	-0.04584	-15.230	21.002	28.583	28.663
150.00	164.96	-0.04049	-15.744	21.008	28.849	28.920
160.00	174.96	-0.03604	-16.231	21.012	29.100	29.164
170.00	184.96	-0.03231	-16.693	21.016	29.338	29.395
180.00	194.96	-0.02914	-17.133	21.019	29.563	29.615
190.00	204.96	-0.02643	-17.552	21.022	29.778	29.824
200.00	214.96	-0.02408	-17.953	21.024	29.982	30.025
210.00	224.96	-0.02205	-18.337	21.026	30.178	30.216
220.00	234.96	-0.02027	-18.704	21.028	30.365	30.400
230.00	244.96	-0.01870	-19.058	21.029	30.544	30.577
240.00	254.96	-0.01732	-19.397	21.031	30.717	30.747
250.00	264.96	-0.01609	-19.725	21.032	30.883	30.911
260.00	274.96	-0.01498	-20.040	21.033	31.042	31.068
270.00	284.96	-0.01400	-20.345	21.034	31.197	31.221
280.00	294.96	-0.01310	-20.640	21.035	31.346	31.368
290.00	304.96	-0.01230	-20.925	21.036	31.490	31.511
300.00	314.96	-0.01157	-21.201	21.037	31.629	31.649
310.00	324.96	-0.01091	-21.469	21.037	31.764	31.783
320.00	334.96	-0.01029	-21.729	21.038	31.895	31.913
330.00	344.96	-0.00974	-21.981	21.038	32.022	32.039
340.00	354.96	-0.00922	-22.226	21.039	32.146	32.161
350.00	364.96	-0.00876	-22.465	21.039	32.266	32.281
360.00	374.96	-0.00833	-22.697	21.040	32.383	32.397
370.00	384.96	-0.00793	-22.924	21.040	32.497	32.510
380.00	394.96	-0.00755	-23.145	21.041	32.608	32.620
390.00	404.96	-0.00721	-23.360	21.041	32.716	32.728
400.00	414.96	-0.00689	-23.570	21.041	32.822	32.833

Table 23: Range Correction Data for Larda Model CX-20

*****API***** ((FREQUENCY= 12.000 GHZ))
DE= 8.46CM DH= 9.22 CM CE= 32.55 CM CH= 31.31 CM
B= 12.65 CM A= 12.65 CM EL= 22.60 CM HL= 24.84 CM

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
3840.54	3858.22	0.00000	-42.689	21.532	42.877	42.877
100.00	117.68	-0.09706	-12.877	21.435	27.817	27.971
110.00	127.68	-0.08210	-13.511	21.450	28.156	28.288
120.00	137.68	-0.07040	-14.106	21.462	28.472	28.585
130.00	147.68	-0.06107	-14.668	21.471	28.767	28.866
140.00	157.68	-0.05351	-15.198	21.479	29.044	29.131
150.00	167.68	-0.04729	-15.699	21.485	29.305	29.382
160.00	177.68	-0.04212	-16.176	21.490	29.551	29.620
170.00	187.68	-0.03776	-16.628	21.495	29.785	29.847
180.00	197.68	-0.03407	-17.060	21.498	30.006	30.062
190.00	207.68	-0.03090	-17.472	21.501	30.217	30.268
200.00	217.68	-0.02817	-17.866	21.504	30.419	30.465
210.00	227.68	-0.02579	-18.243	21.507	30.612	30.654
220.00	237.68	-0.02370	-18.606	21.509	30.796	30.835
230.00	247.68	-0.02187	-18.954	21.510	30.973	31.009
240.00	257.68	-0.02025	-19.289	21.512	31.144	31.177
250.00	267.68	-0.01881	-19.612	21.514	31.308	31.338
260.00	277.68	-0.01751	-19.924	21.515	31.466	31.494
270.00	287.68	-0.01636	-20.225	21.516	31.618	31.645
280.00	297.68	-0.01531	-20.516	21.517	31.765	31.790
290.00	307.68	-0.01436	-20.798	21.518	31.908	31.931
300.00	317.68	-0.01351	-21.071	21.519	32.046	32.068
310.00	327.68	-0.01273	-21.336	21.520	32.180	32.200
320.00	337.68	-0.01201	-21.593	21.520	32.310	32.329
330.00	347.68	-0.01136	-21.843	21.521	32.436	32.454
340.00	357.68	-0.01076	-22.087	21.522	32.558	32.576
350.00	367.68	-0.01021	-22.323	21.522	32.678	32.694
360.00	377.68	-0.00970	-22.553	21.523	32.794	32.809
370.00	387.68	-0.00923	-22.778	21.523	32.907	32.921
380.00	397.68	-0.00879	-22.997	21.524	33.017	33.031
390.00	407.68	-0.00840	-23.210	21.524	33.124	33.138
400.00	417.68	-0.00802	-23.419	21.524	33.229	33.242

Table 24: Range Correction Data for Narda Model 639

*****LSI***** ((FREQUENCY= 15.200 GHZ))

DE= 0.62 CM DH= 1.04 CM CE= 7.31 CM CH= 7.20 CM

B= 3.70 CM(1.8747 LAMDA) A= 5.05 CM(2.5587 LAMDA)

EL= 7.65 CM(3.8760 LAMDA) HL= 8.40 CM(4.2560 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
775.28	776.93	0.00000	-40.877	16.505	36.943	36.943
100.00	101.66	0.01675	-23.200	16.522	28.094	28.105
110.00	111.66	0.01549	-24.014	16.520	28.503	28.512
120.00	121.66	0.01430	-24.759	16.519	28.876	28.884
130.00	131.66	0.01314	-25.445	16.518	29.221	29.227
140.00	141.66	0.01216	-26.081	16.517	29.540	29.545
150.00	151.66	0.01145	-26.673	16.516	29.836	29.841
160.00	161.66	0.01068	-27.228	16.515	30.115	30.119
170.00	171.66	0.01009	-27.750	16.515	30.376	30.380
180.00	181.66	0.00966	-28.242	16.514	30.622	30.626
190.00	191.66	0.00909	-28.708	16.514	30.855	30.859
200.00	201.66	0.00851	-29.150	16.513	31.077	31.080
210.00	211.66	0.00802	-29.571	16.513	31.288	31.290
220.00	221.66	0.00767	-29.972	16.512	31.488	31.491
230.00	231.66	0.00713	-30.356	16.512	31.681	31.683
240.00	241.66	0.00687	-30.723	16.512	31.864	31.866
250.00	251.66	0.00648	-31.076	16.511	32.041	32.043
260.00	261.66	0.00625	-31.414	16.511	32.210	32.212
270.00	271.66	0.00598	-31.741	16.511	32.374	32.375
280.00	281.66	0.00547	-32.055	16.510	32.531	32.532
290.00	291.66	0.00519	-32.359	16.510	32.683	32.684
300.00	301.66	0.00516	-32.651	16.510	32.829	32.831
310.00	311.66	0.00498	-32.935	16.510	32.971	32.972
320.00	321.66	0.00462	-33.210	16.509	33.109	33.110
330.00	331.66	0.00458	-33.476	16.509	33.242	33.243
340.00	341.66	0.00440	-33.734	16.509	33.371	33.372
350.00	351.66	0.00411	-33.985	16.509	33.496	33.497
360.00	361.66	0.00371	-34.229	16.509	33.619	33.619
370.00	371.66	0.00366	-34.466	16.508	33.737	33.738
380.00	381.66	0.00351	-34.697	16.508	33.853	33.853
390.00	391.66	0.00328	-34.922	16.508	33.965	33.966
400.00	401.66	0.00342	-35.141	16.508	34.074	34.075

Table 25: Range Correction Data for Narda Model 638

*****LSI***** ((FREQUENCY= 22.250 GHZ))

DE= 0.45 CM DH= 0.56 CM CE= 5.03 CM CH= 4.67 CM

B= 2.54 CM(1.8838 LAMDA) A= 3.33 CM(2.4697 LAMDA)

EL= 5.07 CM(3.7603 LAMDA) HL= 6.23 CM(4.6206 LAMDA)

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ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
493.46	494.47	0.00000	-40.396	16.438	36.636	36.636
100.00	101.01	0.03336	-26.543	16.471	29.705	29.710
110.00	111.01	0.02975	-27.369	16.468	30.118	30.122
120.00	121.01	0.02674	-28.123	16.465	30.496	30.499
130.00	131.01	0.02414	-28.817	16.462	30.843	30.846
140.00	141.01	0.02208	-29.459	16.460	31.165	31.167
150.00	151.01	0.01993	-30.058	16.458	31.464	31.467
160.00	161.01	0.01831	-30.617	16.456	31.744	31.746
170.00	171.01	0.01692	-31.143	16.455	32.008	32.009
180.00	181.01	0.01545	-31.639	16.453	32.256	32.257
190.00	191.01	0.01395	-32.109	16.452	32.491	32.492
200.00	201.01	0.01295	-32.554	16.451	32.713	32.715
210.00	211.01	0.01206	-32.977	16.450	32.925	32.926
220.00	221.01	0.01132	-33.380	16.449	33.127	33.128
230.00	231.01	0.01035	-33.767	16.448	33.320	33.321
240.00	241.01	0.00960	-34.136	16.447	33.505	33.506
250.00	251.01	0.00867	-34.491	16.446	33.682	33.683
260.00	261.01	0.00800	-34.831	16.446	33.853	33.854
270.00	271.01	0.00763	-35.159	16.445	34.016	34.017
280.00	281.01	0.00712	-35.474	16.445	34.174	34.175
290.00	291.01	0.00650	-35.779	16.444	34.327	34.327
300.00	301.01	0.00578	-36.074	16.444	34.474	34.475
310.00	311.01	0.00539	-36.359	16.443	34.617	34.617
320.00	321.01	0.00492	-36.634	16.443	34.754	34.755
330.00	331.01	0.00481	-36.901	16.443	34.888	34.888
340.00	341.01	0.00419	-37.161	16.442	35.018	35.018
350.00	351.01	0.00350	-37.413	16.441	35.144	35.144
360.00	361.01	0.00276	-37.658	16.441	35.267	35.267
370.00	371.01	0.00283	-37.896	16.441	35.385	35.386
380.00	381.01	0.00198	-38.128	16.440	35.502	35.502
390.00	391.01	0.00196	-38.353	16.440	35.614	35.614
400.00	401.01	0.00190	-38.573	16.440	35.724	35.724

Table 26. Range Correction Data for SA Model 12A-26

*****LSI***** ((FREQUENCY= 35.290 GHZ))

DE= 10.49 CM DH= 9.43 CM CE= 35.37 CM CH= 25.29 CM

B= 5.67 CM(6.6663 LAMDA) A= 6.91 CM(8.1271 LAMDA)

EL= 15.74 CM(18.5160 LAMDA) HL= 16.54 CM(19.4601 LAMDA)

ZAA (CM)	R (CM)	RGAN DB	PRPT DB	NFGAIN DB	RGU DB	RGC DB
3368.89	3388.81	0.00000	-44.504	24.746	46.998	46.998
100.00	119.92	-0.05513	-15.866	24.691	32.541	32.679
110.00	129.92	-0.04390	-16.500	24.702	32.878	32.996
120.00	139.92	-0.03530	-17.095	24.711	33.191	33.294
130.00	149.92	-0.02863	-17.655	24.718	33.485	33.574
140.00	159.92	-0.02343	-18.185	24.723	33.760	33.839
150.00	169.92	-0.01917	-18.685	24.727	34.019	34.089
160.00	179.92	-0.01588	-19.160	24.730	34.264	34.326
170.00	189.92	-0.01310	-19.612	24.733	34.496	34.552
180.00	199.92	-0.01078	-20.042	24.735	34.717	34.767
190.00	209.92	-0.00894	-20.453	24.737	34.927	34.973
200.00	219.92	-0.00731	-20.846	24.739	35.127	35.169
210.00	229.92	-0.00598	-21.223	24.740	35.319	35.358
220.00	239.92	-0.00476	-21.584	24.742	35.503	35.538
230.00	249.92	-0.00380	-21.931	24.742	35.679	35.712
240.00	259.92	-0.00303	-22.265	24.743	35.849	35.879
250.00	269.92	-0.00237	-22.588	24.744	36.012	36.040
260.00	279.92	-0.00176	-22.898	24.745	36.170	36.196
270.00	289.92	-0.00135	-23.199	24.745	36.322	36.346
280.00	299.92	-0.00089	-23.490	24.745	36.468	36.491
290.00	309.92	-0.00037	-23.770	24.746	36.610	36.632
300.00	319.92	-0.00011	-24.043	24.746	36.748	36.768
310.00	329.92	0.00011	-24.308	24.746	36.881	36.900
320.00	339.92	0.00029	-24.565	24.747	37.011	37.029
330.00	349.92	0.00065	-24.814	24.747	37.136	37.153
340.00	359.92	0.00085	-25.056	24.747	37.259	37.274
350.00	369.92	0.00106	-25.292	24.747	37.377	37.392
360.00	379.92	0.00113	-25.522	24.747	37.493	37.507
370.00	389.92	0.00125	-25.746	24.748	37.606	37.619
380.00	399.92	0.00125	-25.965	24.748	37.716	37.729
390.00	409.92	0.00151	-26.178	24.748	37.823	37.835
400.00	419.92	0.00148	-26.386	24.748	37.928	37.939

APPENDIX A

Although multipath does not appear to be a problem in the present NAFS facility, the possibility of multipath errors can be greatly reduced in future measurements by using the following recommendations:

1. Use absorber to cover most of the track between the transmitting and receiving antennas.

2. Measure the coupling data over a 50 cm range interval and determine far-field gain values at points near the middle and the extremes of the interval. A range interval of 250 to 300 cm is recommended for best reliability of the range correction procedure.

One of the most difficult problems with accurate gain measurements is to reliably measure the coupling data with a 0.1 dB accuracy. This requires that good linearity be achieved over the dynamic range of power levels of the measured coupling data and that the system accuracy be maintained. The possibility of inaccuracies in the measured power levels can be reduced by the following recommendations:

1. Periodically calibrate the system (with the waveguides attached) over the usable dynamic range and at the frequencies used.

2. Use a precision RF attenuator inserted between the waveguides to spot check the system calibration whenever the transmitted power or frequency is changed.

3. Use the following four antenna procedure which employs two different antenna designs if possible. This method yields three gain values for each individual horn as a check on the accuracy of the gain measurements.

Detailed Procedure for Calibrating Standard Gain Horn Antennas

The following procedure is recommended as a replacement for the three antenna method of calibrating standard gain horn antennas (Procedure TO 33K-2-12, Section 3-115 of Ref. [2]). This procedure follows the basic procedure described in Ref. [3]. The new recommended procedure uses four antennas rather than three, with two copies each of two different antenna designs. The basic procedure is outlined below:

A. Measure the coupling over a 50 cm range interval (use approximate aperture separations of 250 cm to 300 cm) for each of the following antenna pairs, using two antennas of type A (e.g. Scientific Atlanta horns) and two antennas of type B (e.g. Narda horns). This gives on-axis coupling data for the following six combinations of antenna pairs:

TABLE A-1
Coupling Combinations for the Four Antenna Method

1. A1/A2
2. A1/B1
3. A1/B2
4. A2/B2
5. A2/B1
6. B2/B1

If only one horn model is available for the frequency band, use four horns of that model.

B. Use the OSU procedure for finite range correction to determine the effective far-field gain (mean value of the two antenna gains) of each of the above six antenna combinations. Determine gain values for three range distances with each combination, e.g., at 250, 275 and 300 cm.

If the gain values for the three distances agree to the desired accuracy (say, within 0.1 dB) proceed to the next step.

If not, re-check the measurement for that combination. Gain values at other distances in the 50 cm range interval can be processed as an aid in checking discrepancies.

C. Use the average value of the gains determined at the three distances for each of the six combinations in step B in the following way: Calculate values of the far field gain for each individual antenna using the approach of the three antenna method. See the following table:

TABLE A-2

Gain Values From the Four Antenna Method

Coupling Measurements	Individual Antenna Gains
1, 2, 5	A1, A2, B1
1, 3, 4	A1, A2, B2
2, 3, 6	A1, B1, B2
4, 5, 6	A2, B1, B2

For example, as seen from Table A-2, the effective gains determined from the coupling measurements 1, 2 and 5 are solved for the individual antenna gain values A1, A2 and B1, etc.

The advantage of the four antenna procedure is that it gives three values for the far field gain of each antenna as can be seen from the above table. Under steps 4.1.7 through 4.1.9 of Procedure TO 33K-2-12, Section 3-115 of Ref. [2] for the three antenna method, six coupling measurements are also made. However, each antenna pair is measured twice; in the second measurement the antennas are switched in their roles as transmitter and receiver. By reciprocity the measured coupling should be the same when the transmitter and receiver are interchanged. The redundancy provided by reciprocity is not likely to uncover

any measurement errors caused by system non-linearity or room multipath effects because the same two horns are measured together twice. The use of two different sizes or types of horns gives a more independent check of system linearity if the two horns have substantially different gain levels. Similarly, different horn sizes will give a better check on possible room multipath effects because their patterns will be substantially different.

The fact that three sample values of gain are determined for each antenna provides a good check on the reliability and accuracy of the measurements. For example, the accuracy of the measured gain will be no better than the spread between the three gain values for each horn. Furthermore, the use of a 50 cm range interval rather than a fixed distance as specified in step 4.1.5 of Procedure TO 33K-2-12, Section 3-115 of Ref. [2] provides added reliability in the measurements.

Four Antenna Method

The detailed steps of the four antenna method are outlined below:

1. Measure and record the axial length of each horn to be measured (from waveguide flange to aperture plane).

2. With waveguides attached, set frequency and set transmitter power level so that all estimated coupling levels will fall within the calibrated dynamic range.[1]

3. With waveguides still attached, record a transmitted power reference using a directional coupler.

4. Unclamp waveguides and separate so that a precision RF attenuator can be inserted. Record several spot checks in the range of coupling levels that are expected to occur.

5. Remove attenuator and attach first horn antenna pair. Bring antennas into contact so that apertures are flush.

6. Record measured coupling versus waveguide flange separation for the first antenna combination over the full range (out to an aperture separation of at least 300 cm). Check transmitted power reference at end of run. Use measured horn lengths to determine and mark on recorded coupling chart the locations of aperture separations at approximately 250, 275 and 300 cm.[2]

7. Record the measured coupling for the next four combinations of horn antenna pairs over a limited range of separations (approximately 250 cm to 300 cm between apertures). Assure that constant power is maintained by checking and recording transmitted power reference at the beginning and end of the run for each horn antenna pair.

Use the measured horn lengths to determine and mark the chart locations of three aperture separations (e.g. 250, 275 and 300 cm).[2]

8. Record the measured coupling for the sixth antenna combination over the full range using a reverse of step 6. Check recorded separation with horn apertures flush.

   Remove antennas and attach waveguides. Check and record chart locations with waveguides attached. Record coupling power level and transmitter power reference from directional coupler.

9. Use the finite range correction procedure to determine the effective far-field gain for each of the six antenna combinations. Determine gain values at three range distances to check the measurement for each antenna combination as outlined in step B above.

10. Use the three antenna method four times to calculate three sample values for each individual antenna as outlined in step C above.

The recording of coupling versus waveguide flange separation and the use of a 50 cm range interval in the above method provides a relatively fast way of taking the coupling measurements since each antenna pair is not required to traverse the whole track. However, care must be taken to properly calculate and record the aperture separations by use of the horn lengths measured in step 1.

If desired, the more lengthy procedure of bringing each antenna pair into contact and recording coupling versus aperture separation over the entire range can be used. However, this should not be necessary if reasonable care is exercised in using the measured horn lengths to determine aperture separation; average coupling levels (i.e., with antenna to antenna interaction ripple removed) are not sensitive to variations of a centimeter or so in range.

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(1) The dynamic range of the measuring system should be calibrated with a precision attenuator at periodic intervals and whenever the system has been modified.

(2) Note that the exact values of the aperture separations used is not important as long as they are precisely known and the proper range correction is used.

REFERENCES

1. H. H. Chung and R. C. Rudduck, "Near Field Correction Curves for Standard Gain Horn Antennas," Report 711587-1, March 1980, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract N00014-76-A-0039-RZ01 for 2750th Air Base Wing/PMR, Specialized Procurement Branch.

2. "Calibrations Procedures (Standards - Air Force Level)," Technical Manual TO 33K-2-12 published under the authority of the Secretary of the Air Force, 30 August 1978.

3. R. R. Bowman and W. E. Jessen, "Calibration Techniques for RAMCOR Densitometer Antennas," Final Report No. CCG69-27, National Bureau of Standards Report 9776, December 21, 1970.